Life Safety Report

The Sheraton Hotel at
Downtown Phoenix
340 North 3rd Street
Phoenix, Arizona 85004

Client:

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Keyword: Sheraton Hotel Downtown Phoenix, Life Safety Code, Performance Based Design, Fire Dynamics Simulator (FDS), and Egress Analysis.

ABSTRACT

This report evaluates the prescriptive life safety requirements for levels one (1) through four (4) of the Sheraton Hotel in downtown Phoenix. In addition, this report discusses two fire scenarios that evaluate the tenability during egress the in pre-function area on level two (2) and in the main ballroom on level three (3) of the hotel.

The prescriptive standards/codes used to evaluate the hotel are the International Building Code (IBC), International Fire Code (IFC), and applicable standards from the National Fire Protection Association (NFPA). Performance based analysis were conducted using Pathfinder, CFast, and Fire Dynamic Simulator (FDS). Two fire scenarios were picked in this performance based analysis. The first scenario was a couch fire in the main lobby that had an atrium that shared space with the pre-function area on level (2). The second scenario was a kiosk fire in the main ballroom on level three (3). The Sheraton Hotel complied with the majority of the code requirements.

There are two areas that did not meet the mean egress requirements. The terrace on level two (2) had an exit separation issue and the main ballroom north doors on level (3) had an encroachment issue in the vestibules used to egress. It is recommended to re-locate the doors on the terrace area to meet the exit separation code. For the encroachment issue, it is recommended to increase the width of the vestibules or to classify the doors as service doors rather than egress doors.

The performance analysis determined the couch fire scenario in the lobby created an environment in the pre-function area on level (2) that does not meet the tenability requirements. A recommendation is to provide glass wall partitions in between the pre-function area and atrium in order to meet tenability requirements. The second performance based analysis determined that a kiosk fire the main ballroom is able to maintain tenability during egress of the occupants as well as to validate that propagating flame spread from the fire source is not a concern in the ballroom. The proposed recommendations in this report are based on the code review and performance based analysis.

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Life Safety Report – Sheraton Phoenix Downtown

Introduction

Description of Project

This project is an evaluation of an existing hotel in the downtown Phoenix metropolitan area. The hotel features over 1,000 guest rooms, 47 suites, assembly rooms, meeting rooms, a restaurant, a gym, and a pool. Sheraton hotel is located in the heart of downtown Phoenix and provides visiting guests a temporary residence when attending conventions, professional sport games, business meetings, and/or vacation trips. The hotel has 31 floors and 2 basement levels below grade. The main evaluation in this project focuses on levels one (1) through four (4) of the hotel.

Figure 1 below is a picture of the building.

Figure 1: Sheraton Hotel

The areas and uses of the levels being evaluated are shown in Table 1 below:

Table 1: Area usage of the Sheraton Hotel by levels

Level	Gross Floor Area (sq. ft.)	Occupancy Descriptions
Ground floor	112,513	Business B, Mercantile M, Kitchens A-2, and Storage S-1
2ndFloor	112,513	Assemblies A-3, Business B, and Storage S-1
3rd Floor	90,391	Assemblies A-3, Business B, and Storage S-1
4th Floor	50,562	Assemblies A-3, and Storage S-1

The floors are to be discussed in further detail throughout the report.

Project Codes and Standards

The building in this report is reviewed using the following building code and standards:

- International Building Code (IBC) – 2012 Edition
- International Fire Code (IFC) – 2012 Edition
- NFPA 101 - Life Safety Code – 2012 Edition
- NFPA 13 – Standard for the Installation of Sprinklers Systems – 2013 Edition
- NFPA 14 – Standard for Installation of Standpipe and Hoses Systems – 2010 Edition
- NFPA 20 – Standard for the Installation of Stationary Pumps for Fire Protection – 2013 Edition
- NFPA 25 – Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems – 2011 Edition
- NFPA 72 – National Fire Alarm and Signaling Code – 2013 Edition
- NFPA 96 – Standard for Ventilation Control and Fire Protection of Commercial Cooking Operation – 2011 Edition
- NFPA 17A – Standard for Wet Chemical Extinguishing Systems – 2009 Edition

This report is an architectural review of the building and the fire code impacts on the project. The main focus of the building critique will be using the IBC code.

Report Objectives

The purpose of this report is to evaluate various aspects of the egress system of the Sheraton Hotel in the Phoenix downtown area.

This report should be used in conjunction with the construction plans and life safety sheets. The life safety sheets will provide occupancy classifications, occupant loads, and egress width provisions.

The Sheraton hotel was designed and built under the International Building Code. This report will also include a performance based analysis of the building. Two fire scenarios are identified later in this report that will evaluate the current building design egress capabilities.

Site Plan and Fire Services Features

Fire Department Access

Access Roads

In IFC Section 503 fire apparatus access roads requirement are stated. It is stated that the access road shall extend within 150 feet of all portion of the facility and all portions of the exterior walls of the first story of the building. There are exceptions to the Section 503, if an access road cannot be installed due to location on property, topography, waterways, nonnegotiable grades or other similar conditions and an approved alternative means of fire protection is provided. The access is to be approved by the fire department around the exterior of the building. The Fire Code official is authorized to require additional access roads based upon the potential for impairment of a single road by vehicle congestion, terrain, climatic condition or other factors that could limit access.

Fire apparatus access road specifications and dimension for the project are as follows:

- Minimum unobstructed vertical clearance is 41 feet.
- Minimum unobstructed road width is 20 feet
- The surface of the access road is all weather diving capabilities.
- Turning radii is not necessary since the building in in the middle of the street
- The grade does not have a slope. Flat surface.

The location of the Sheraton complies with the access apparatus access road specification.

Building / Roof Access

The requirement for the building and roof access can be found in the IFC Section 504. All exterior floors and openings shall be maintained readily accessible for emergency access by the fire department according to 504.1 Section. Any access not working must have a sign stating “THIS DOOR BLOCKED” according to 504.2 sections.

According to IBC Section 1009.11.1 provides that for unoccupied roofs, the access hatch shall be permitted to be a roof hatch or trap door. Newer buildings must provide access to the roof according to IFC 504.3

The Hotel has an exterior access stairway to the roof of level four (4). The roof access to the roof above level 31 is through the interior stairwell of the building. This meets the requirement set forth in the IFC and IBC.

Address Identification

Per IFC Section 505 the premise identification must have an approved address number and place in a position where is plainly visible and legible from the street or road.

The hotel has legible identification address.

Key boxes

Key boxes are to be installed per Section 506 of the IFC. The key boxes shall be installed where it can be immediately be accessed by fire fighters for life safety purposes. The box shall be made according to UL 1037 and shall contain keys to gain necessary access as required by the fire code official.

The key boxes are located in the Fire Command Room located in the first floor near the electrical service area.

Fire Flow, Fire Hydrants, and Firefighting Service Connections

Fire Flow

Per Section 507.3 Fire flow requirements for a building or portions of building and facilities shall be determined by an approved method

Water flow test was conducted in order to confirm adequate water flow for this building..

Fire Hydrants

Fire hydrant location must not be more than 400 feet form a fire apparatus access road per Section 507.5.1 of the IFC code.

The fire hydrant is located around the building. Fire hydrants are provided by the Phoenix water department.

Fire Command Center

The Fire Command Center (FCC) is located on the north east side of the building adjacent to the switch gear room. The FCC is required to meet with the requirements of Section 911 of the IBC and Section 508 of the IFC. Both code books state the same requirements and from this section the IBC sections will be referenced. The construction requirements that the FCC must comply with are a minimum of 1 hour fire barrier and that the room shall be at least 200 ft^2 with a minimum dimension of a 10 ft. wall. These requirements are based on Section 911.1.2 and 911.1.3 of the IBC. The room does meet the construction requirements.

The required features for the FCC are stated in Section 911.1.5. The following is what can be found in the Sheraton Hotel's FCC.

- Emergency communication systems control unit
- Fire department communication system
- Fire detection and alarm system annunciator
- Annunciator unit visually indicating the location of the elevators and whether they are operational
- Status indicators and controls for the air distribution systems
- Fire-fighters control panel per Section 909.16
- Controls for unlocking stairway doors
- Sprinkler valve and water flow detector display panel
- Emergency standby power status

- A telephone for fire department use
- Fire pump indicators
- Schematic building plans
- An approved building information card
- Work table
- Generator supervision devices, manual start, and transfer features
- Elevator fire recall switch in accordance with ASME A17.1
- Elevator emergency or standby power selector switch

The fire command center was found compliant with the IBC requirements.

Building Fire Protection and Life Safety Features

Occupancy Classification and Separation

The IBC indicates the following occupancy classification for areas in the building, Table 2 below summarizes the occupant classifications found throughout level 1 to level 4:

Table 2: Occupancy classification

Use of Space/Area	Occupancy Classification
Dinning	A-2
Ballrooms/Gym	A-3
Offices	B
Stores	M
Moderate hazard storage/Parking	S-1
Low hazard storage	S-2

Occupancy Separations

This building is designed according to the non-separated occupancy provisions. The building does not need to comply with the occupancy separation table in IBC Table 508.4, but needs to comply with IBC Section 508.3

508.3 Non-separated occupancies. Building or portions of buildings that comply with the provisions of this section shall be considered as non-separated occupancies.

> *508.3.1 Occupancy Classification. Non-separated occupancies shall be individually classifies in accordance with Section 302.1. The requirements of this code shall apply to each portion of the building based on the occupancy classification of that space. In*

addition, the most restrictive provisions of Chapter 9 shall apply to the total non-separated occupancies shall apply to the total non-separated area. Where non-separated areas occupancies occur in a high rise building, the most restrictive requirements of section 403 which apply to the non-separated occupancies shall apply throughout the high-rise building.

508.3.2 Allowable building area and height. The allowable building area and height of the building or portion thereof shall be based upon the most restrictive allowances for the occupancy groups under consideration for the type of construction of the building in accordance with section 503.1

508.3.3 Separation. No separation is required between non-separated occupancies.

Exceptions:

1. *Group H-2, H-3. H-4, and H-5 occupancies shall be separated from all other occupancies in accordance with Section 508.4*
2. *Group I-1, R-1, R-2, and R-3 dwelling units and sleeping units shall be separated from other dwelling or sleeping units and from other occupancies contiguous to them in accordance with the requirements in section 420.*

This building is a high rise type I-A construction with a sprinklered system that allows the building the occupancies to be individually classified. The building has an unlimited height and in area criteria.

Incidental Use Areas

Incidental areas shall be classified according to the main occupancy. Fire barriers shall be used to separate these areas unless otherwise noted by IBC Table 509. When IBC permits protection by an automatic fire-extinguisher without fire-barriers, the walls enclosing the incidental use area must simply resist the passage of smoke. Table 3 shows the applicable incidental use areas for this particular building.

Table 3: Fire barrier requirements for incidental use areas

ROOM OR AREA	SEPARATION AND/OR PROTECTION
Furnace room where any piece of equipment is over 400,000 Btu per hour input	1 hour or provide automatic sprinkler systems
Rooms with boilers where the largest piece of equipment is over 15 psi and 10 horsepower	1 hour or provide automatic sprinkler systems
Refrigerant machinery room	1 hour or provide automatic sprinkler systems
Laundry room over 100 square feet	1 hour or provide automatic sprinkler systems
Waste and linen collection rooms over 100 square feet	1 hour or provide automatic sprinkler systems

The building has an automatic fire sprinkler system; IBC would allow omitting the 1 hour fire barrier for the furnace, boiler, refrigerant machinery, laundry, and waste linens rooms due to the fact that the service areas have fire sprinklers. Instead of the fire barriers, smoke barriers are required to be installed in the laundry rooms, utilities room, and air conditioning units. The doors on the rooms shall be self or automatic-closing upon detection of smoke. The door shall not have air transferring openings and shall not be undercut in excess of the clearance permitted in accordance with NFPA 80.

Building Heights, Areas, and Construction Type

Building Height and Areas

Section 503 of the IBC states the limitations on building heights and areas for a particular building. The requirements are based on the occupancy and construction type of the building. The Sheraton Hotel in Phoenix is a high rise mixed occupancy building. Looking at IBC Table 503 the construction type of the building will fall under Type I-A classification, which has an unlimited height and area criteria.

Construction Type and Fire Resistance Requirements

Table 601 from the IBC gives the prescriptive fire resistance rating for different building elements. Since this building is considered a High Rise building according to section 403 of the IBC the type of construction fall under type I-A. However the building complies with an exception because the building has automatic sprinkler systems and the building is less than 420 feet in height. The exception allows the fire resistance rating to be reduced as if the building were constructed with type I-B materials. This is true for all the building elements with the exception of the supporting columns. This stated in Section 403.2.1.1 of the IBC.

403.1 Applicability. High-rise building shall comply with section 403.2 through 403.6

403.2 Construction. The construction of high-rise buildings shall comply with the provisions of section 403.2 through 403.4.

403.2.1 Reduction in fire resistance rating. The fire resistance-rating reduction listed in Section 403.2.1 and 403.2.1.2 shall be allowed in building hat have sprinkler control valves equipped with supervisory initiating devices and water-flow initiating device for each floor.

403.2.1.1 Type of construction. The following reductions in the minimum fire-resistance rating of the building elements in table 601 shall be permitted as follows:

1. Buildings not greater than 420 feet (128000 mm) in building height, the fire-resistance rating of the building element in Type IA construction shall permitted to be reduced to the minimum fire-resistance rating for the building elements in Type IB.

Exception: The required fire resistance rating in columns supporting floors shall not be permitted to be reduced.

2. In other than Group F-1, M, and S-1 occupancies, the fire-resistance rating of the building element in Type IB construction shall be permitted to be reduced to the fire resistance rating in Type IIA.

403.2.1.2 Shaft enclosures. For buildings not greater than 420 feet (128000 mm) in building height, the required fire-resistance rating of the fire barriers enclosing vertical shafts, other than exit enclosures and elevator hoist way enclosures, is permitted to be reduced to 1 hour where automatic sprinklers are installed within the shaft at the top and at alternate floor levels.

403.2.4 Sprayed fire-resistant material (SFRM). The bond strength of the SFRM installed throughout the building shall be in accordance with Table 403.2.4

Table 403.2.4 – Minimum Bond Strength

HEIGHT OF BUILDING	*SFRM MINIMUM BOND STRENGTH*
Up to 420ft.	*430 psf*
Greater than 420 ft.	*1,000 psf*

Using *Table 601 Fire-resistance rating requirements for building elements (hours)* the required fire resistance rating elements can be obtained. Table 4 condenses IBC Table 601 with applicable ratings for this hotel building.

Table 4: Applicable Table 601 fire-resistance rating requirements

Building Element	Rating (Hours)
Primary Structural Frame	3
Bearing Wall – Exterior	2
Bearing Wall – Interior	2
Non Bearing Wall – Exterior	2
Non Bearing Wall – Interior	0[a]
Floor Construction and Associated Secondary Members	2
Roof Construction and Associated Secondary Members	1

[a] 1 hour fire resistance is needed in R-1 and S-1 occupancies

Use of Combustible Materials in Type I and Type II Construction

Allowable material in this building construction can be found in the IBC Section 603.

For this particular building the construction Type I or Type II can be used.

Fire Resistive Construction

General Fire Resistive Construction

Chapter 7 of the IBC has requirements for fire resistive construction and different types of rated walls and assemblies. The following are the examples of fire resistive construction requirements that can be found in the chapter.

- Exterior walls
- Fire walls
- Fire barriers
- Fire partitions
- Smoke barriers
- Smoke partitions
- Horizontal assemblies
- Vertical openings
- Shaft enclosures
- Penetrations
- Fire-resistant joint systems
- Opening protective
- Ducts and air transfers openings
- Concealed spaces

Fire Resistance for Structural Members

It is required for the columns to be completely encased by the proper fire–resistance rated enclosure per Section 704.2. Since the building is Type I-A, the enclosures for the columns

shall be a 3 hour rating enclosure. Even with an automatic sprinkler system installed, columns shall not be reduced to type I-B construction fire rating.

Protection of primary structural frame other than the column shall have a complete encasing of fire-resistive material on all sides and to its full length, including connections to other structural members. Type I-A fire resistant rating requirements can be reduced to Type I-B rating since the building has automatic sprinklers.

Load bearing exterior wall shall have the highest fire resistive rating in accordance to table 601 and 602. See Section 704.10 of the IBC code. For this building the exterior fire resistant rating is 2 hours.

Fire resistance material has been sprayed to meet fire resistance rating requirement per statements in IBC Section 704.13 and with the manufacturer's installation instructions.

Fire Resistive Components

Exterior Walls – Fire Resistance Rating

Section 705 of the IBC states requirements of the exterior walls. The location of exterior walls compared to the Fire Separation Distance (FSD) determines the fire resistive rating. The FSD is defined in section 202 in the definition chapters.

Fire Separation Distance (FSD) – The distance measured from the building face to one of the following:

1) *The closest interior lot line*
2) *To the centerline of a street alley or public way; or*
3) *To an imaginary line between two building on the property.*

The distance shall be measured at right angles from the face of the wall.

IBC Table 602 provides the requirement of the exterior wall fire-resistive rating using the FSD of the exterior wall. The Table 5 below condenses the applicable parts of IBC Table 602.

Table 5: Applicable Fire Separation Distance

Fire Separation Distance = X (feet)	Occupancy Group F-1, M, S-1	Occupancy Group A, B, E, F-2, I, R, S-2, U
X <5	2	1
5 <= X < 10	1	1
10 <= X < 30	1	1
X >= 30	0	0

There is a retail area that falls under the Mercantile category that requires a 2 hr. fire resistance rating. The other portions of the building can be a 1 hr fire resistant material. See Appendix A the location of where the 2 hr. fire resistance is needed.

Section 705.8 in the IBC states the allowable opening percentage in the exterior walls of the building. Table 6 shows the applicable maximum area allowed per IBC Table 705.8:

Table 6: Applicable maximum area of exterior wall openings based on FSD

Fire Separation Distance (ft.)	Degree of Opening Protection	Allowable area
0 to less than 3	Unprotected, Nonsprinklered (UP, NS)	Not Permitted
	Unprotected, Sprinklered (UP, S)	Not Permitted
	Protected (P)	Not Permitted
3 to less than 5	Unprotected, Nonsprinklered (UP, NS)	Not Permitted
	Unprotected, Sprinklered (UP, S)	15%
	Protected (P)	15%

Due to sprinkler systems being installed, protected openings and vertical opening sections (705.8.2 and 705.8.5) do not apply to this building. Exterior fire joints shall have the fire resistance per section 715.

Fire Barrier

Fire barrier are used in the following separations:

- Shafts, mechanical egress
- Exit enclosures
- Exit passage ways
- Horizontal exits
- Atriums
- Occupancy separations

In this building fire barrier are used in exit passageways and exit enclosures and shall comply with these requirements.

The IBC Section 707.5 shall have fire barriers that extend from the floor to the ceiling and any supporting construction shall require fire resistance rating.

The hotel has a fire resistive rating of 2 hours.

Fire Partitions

IBC Section 708 mentions the regulations for fire partitions. These fire partitions are used for the following separations.

- Walls separating sleeping units in the same building as required in section 420.2
- Fire resistive rated corridors required by section 1018.1
- Elevator lobby separation required by section 713.14.1

It is important to realize that the fire partition shall extend from the top of the foundation or floor/ceiling assembly below to the underside of the floor or sheathing.

Elevator lobbies have a fire resistance rating of 2 hours.

Smoke Partitions

IBC Section 710 states that smoke partitions is not required to have a fire resistive rating unless stated in other section in the IBC code.

Smoke partitions extend from the top of the foundation to the underside of the floor deck or slab above or to the underside of the ceiling above where the ceiling membrane is constructed to limit transfer of smoke.

Opening such as windows shall be sealed in a manner that will not allow smoke to pass through and doors shall comply with Section 710.5.2.1 through 710.5.2.3 of the IBC.

> *IBC 710.5.2.1 Louvers. Doors in smoke partitions shall not include louvers.*
>
> *IBC 710.5.2.2 Smoke and draft control doors. Where required elsewhere in the code, door in smoke partitions shall meet the requirements for a smoke and draft control door assembly tested in accordance with UL 1784. The air leakage rate of the door assembly shall not exceed 3.0 cubic feet per minute per square foot of door opening at 0.10 inch of water for both the ambient temperature test and the elevated temperature exposure test. Installation of smoke door shall be in accordance with NFPA 105.*
>
> *IBC 710.5.2.3 Self or automatic-closing doors - Where required elsewhere in the code, doors in smoke partitions shall be self- or automatic-closing by smoke detection in accordance with section 716.5.9.3.*

This building will require smoke partition in the mechanical/equipment rooms and storage rooms.

Horizontal (floor, ceiling, and roof) assemblies

The section that regulates these assemblies is IBC Section 711. Fire resistivity rating must be applied to the following on one of the following types of construction areas:

- The type of construction of the building
- Occupancy separation requirements
- Fire area separations

The hotel falls under the requirement of 1 hour fire resistive materials for its floors, ceilings, and roof assemblies. The Hotel meets the requirements.

Opening and Penetrations of Fire-Resistance-Rated Assemblies

Penetrations

IBC Section 714 of the IBC regulates the through penetrations and membrane-penetrations. All penetrations through the fire resistance rated assemblies must be done according to this section.

Through penetration must be protected with by an approve penetration fire stop system that has been tested according to ASTM E 184 or UL 149.

The hotel has been constructed to meet this section. Fire stop was used in approved penetrations.

Joints between Fire Resistive Rating Assemblies

The joints between fire-resistive rated walls, floors, and roofs shall be protected by an approved fire resistant joint system designed to resist the passage of fire for the time period not less than the required fire resistive rating for the wall, floor, or roof per IBC Section 715.1

In Section 715.1, there are some exceptions to be applied to fire resistance rating joints. The following are locations where these fire resistive rating are not required:

- Floors where the joint is protected by a shaft enclosure in accordance with Section 713
- Floors with atriums where the space adjacent to the atrium is included in the volume of the atrium for smoke control purposes.
- Floors and ramps within open an enclosed parking garages or structures constructed in accordance with IBC Section 406.5 and 406.6
- Mezzanine floors.

Joints systems where used in the hotel with the exception of the main lobby atrium in level one (1) as well as mezzanines on level one (1) and level three (3) of the hotel.

Interior Opening Protection

Section 716 regulates the opening protection of the buildings. Table 7 summarizes the general requirement for fire doors and shutters.

Table 7: Applicable opening fire protection assemblies and ratings

Type of Assembly	Required Assembly Rating (hrs.)	Min. Fire-door or shutter assembly Rating (hrs.)
Firewalls & fire barrier having a required fire-resistance rating greater than 1 hour	4	3
	3	3
	2	1 ½
	1 ½	1 ½
Fire barriers having a required fire-resistance rating of 1 hour for shaft exit enclosures and exit passageway walls	1	1
	1	¾
Fire partitions: Corridor Walls Other Fire partitions	1	1/3
	0.5	1/3
	1	¾
	0.5	1/3
Exterior Walls	3	1 ½
	2	1 ½
	1	¾
Smoke Barriers	1	1/3

Section 716.5 also states that fire doors and shutter shall also comply with NFPA 80.

Section 716.5.9.3 also states that smoke-activated doors shall be installed on the following locations followed by a 10 second delay before closing:

- Doors installed across corridors
- Doors that protect openings in exit or corridors required to be of fire-resistance rated construction.
- Doors that protect opening in walls that are capable of resisting the passage of smoke in accordance with Section 509.4
- Doors installed in smoke barriers in accordance with Section 709.5
- Doors installed in fire partition in accordance with Section 709.6
- Doors installed in a fire wall in accordance with Section 709.8
- Doors installed in refuse and laundry chutes and access and termination rooms in accordance with Section 713.13. Automatic-closing chute intake doors installed in refuse and laundry chutes shall also meet the requirements of Section 716.5.9 and 713.5.9.1.1
- Door installed in the walls for compartmentation of underground building in accordance with Section 405.4.2
- Doors installed in the elevator lobby walls of underground building in accordance with Section 405.4.3
- Doors installed in smoke partitions in accordance with Section 710.5.2.3

The IBC section also gives the requirement of windows and fire protection rated glazing in Section 716.6. The fire glazing must also comply with NFPA 80. Table 8 summarizes the requirements.

Table 8: Applicable glazing fire resistance and rating requirements

Type of Assembly		Required Assembly Rating (Hours)	Minimum Fire Window Assembly Rating (Hours)
Interior Walls	Fire Walls	All	Not Permitted
	Fire Barriers	>1 1	Not Permitted ¾
	Fire Partitions	1 ½	¾ 1/3
	Smoke Barriers	1	¾
Exterior Walls		>1 1	1-1/2 ¾
Part Walls		All	Not Permitted

(a) Not permitted, except fire resistance rating assemblies tested to ASTM E 119 or UL 263, as specified in IBC Section 716.2

When water curtains are provided on the exterior walls are rated the openings are not required to be rated.

The hotel complies with this section. The doors and windows on smoke barrier assemblies comply with the door fire rating of 1/3 and window assembly rating of ¾. Exterior wall assembly rating in the mercantile area is over 1 hour. The doors and windows assemblies for the mercantile area is rated to 1 ½ hours. There are no water curtains installed in the building.

Duct and Air Transfer Openings

IBC section 717 has the requirements for ducts and air transfer openings. Dampers shall have listed approval per Section 717.3.1, which states fire dampers shall pass UL 555, smoke damper shall pass UL 555S and combination of fire and smoke shall pass both standards. If the damper has a ceiling radiation requirement than the damper needs to comply with UL 555C.

Table 9 shows the applicable fire damper rating of Table 717.3.2.1 of the IBC.

Table 9: IBC Table 717.3.2.1

Type of Penetration	Minimum Damper Rating (Hours)
Less than 3 hours fire resistance rated assemblies	1-1/2
3 hour or greater fire resistance rated assemblies	3

The fire damper actuation device must follow one of the following requirements per Section 717.3.3.1

1) Operating temperature is approximately 50°F (10°C) above normal temperature of the duct system, but not less than 160°F (71°C).
2) The operating temperature is not to exceed 350°F (177°C) when located in a smoke control system per section 909

Table 10 summarizes Section 717.5 details where fire dampers, smoke dampers, and combination fire/smoke dampers are required.

Table 10: Break down of fire, smoke, combo, damper requirements

Location	Fire Damper	Smoke Damper	Combination Fire/Smoke	Notes
Exterior Walls	X			Section 717.5.6
Fire Walls	X			Section 717.5.1
Horizontal Exits			X	Section 717.5.1.1
Fire Barriers	X			Section 717.5.2 Some Exceptions
Shaft Enclosure			X	Section 717.5.3 Some Exceptions
Fire Partitions	X			Section 717.5.4 Some Exceptions
FRR Corridors			X	Section 717.5.4.1 Some Exceptions
Smoke Barriers		X		Section 717.5.5 Some Exceptions
Smoke Partitions		X		Section 717.5.7 Some Exceptions
Horizontal Assemblies	X			Section 717.6.1 Some Exceptions

The hotel's Heating, Ventilation, and Air Conditioning (HVAC) and smoke control systems meets the applicable requirement of this section.

Concealed Spaces

Concealed spaced are mentioned in Section 718 of the IBC code. Since this building is a Type IA construction, it is limited to just requirement stated in Section 718.5

718.5 Combustible materials in concealed spaces in Type I or II construction. Combustible material shall not be permitted in concealed spaces of buildings of Type I or II construction.

Exceptions:

1) *Combustible material in accordance with IBC Section 603.*
2) *Combustible materials exposed within plenums complying with Section 602 of the International Mechanical Code.*
3) *Class A interior finish materials classified in accordance with Section 803.*
4) *Combustible piping within partitions or shaft enclosures installed in accordance with the provisions of this code.*

5) *Combustible piping within concealed ceiling spaces installed in accordance with the International Mechanical Code and the International Plumbing Code.*
6) *Combustible insulation and covering on pipe and tubing, installed in concealed spaces other than plenum, complying with Section 720.7*

Combustible materials in concealed space were not allowed during construction in order to comply with this section.

Interior Finish

Chapter 8 of the IBC book discusses the interior finishes of a building. Section 803.1 states that all interior wall and ceiling finish material need to be classified with Section 803.1.1 or 803.1.2 with exception to Section 803.2 through 803.13. The material tested in accordance to 803.1.2 does not need to be tested in accordance to 803.1.1.

Below is the classification of interior wall and ceiling finish material in Section 803.1.1

This classification is in accordance to ASTM E 84 of UL 723.

Class A = Flame spread index 0-25; smoke developed index 0-450

Class B = Flame spread index 26-75; smoke developed index 0-450

Class C = Flame spread index 76-200; smoke developed index 0-450

The exception to this classification is given in Section 803.1.2 which requires the material to pass the acceptance criteria for NFPA 286. The requirements are:

1) During the 40 kW exposures, flames shall not spread to the ceiling.
2) The flame shall not spread to the outer extremity of the sample on any wall or ceiling.
3) Flashover, as defined in NFPA 286, shall not occur.
4) The peak heat release rate throughout the test shall not exceed 800 kW.
5) The total smoke released throughout the test shall not exceed 1,000 m^2

Thicknesses other than textiles that are thinner than 0.036 inches applied to the surfaces of the walls do not need to pass a particular test, according to section 803.2

IBC 803.4 Foam plastics should not be used unless it follows the requirement of Section 2603.10.

IBC 803.5 Textile wall covering shall comply with requirements in Section IBC 803.1.2, 803.1.3, or 803.1.4

IBC 803.6 Textile ceiling covering shall comply with requirements in IBC Section 803.1.2 or 803.1.4

IBC 803.7 Expanded vinyl wall covering shall comply with requirement in IBC Section 803.1.2, 803.1.3, or 803.1.4

IBC 803.8 Expanded vinyl ceiling covering shall comply with requirements in section IBC Section 803.1.2 or 803.1.4

Flame spread index shall not have a flame spread index specified in IBC Table 803.9 for group and location designated. Any materials that pass the NFPA 286 criteria in section 803.1.2 can be used where a Class A fire classification is specified using the ASTM E 84 test protocols.

Table 11 below shows the excerpts of the applicable sections for this building. The hotel has automatic fire sprinklers which allow the interior finish classification to be decreased.

Table 11: Applicable interior finish requirement

GROUP	Sprinklered[C]		
	Interior exit stairways, interior exit ramps and exit passage ways [a, d]	Corridors and enclosure for exit access stairways and exit access ramps	Rooms and enclosed space [b]
A2	B	B	C
A3	B	B	C
B/M	B	C	C
S	C	C	C

Notes:

(a) Class C interior finish materials shall be permitted for wainscoting or paneling of not more than 1,000 SF of applied surface are in the grade lobby where applied directly to a noncombustible base or furring strips applied to a noncombustible base and fire blocked as required by section 80.1.1

(b) Requirements for room and enclosed spaces shall be based upon spaces enclosed by partitions. Where a fire-resistance rating is required for structural elements, the enclosing partitions shall extend from the floor to the ceiling. Partitions that do not comply with this shall be considered enclosing spaces and the rooms or spaces on both sides shall be considered one. In determining the applicable requirements for rooms and enclosed spaces, the specific occupancy thereof shall be the governing factor regardless of the group classification of the building.

(c) Applies when spaces are protection by an automatic fire sprinkler system installed in accordance with NFPA 13.

(d) In other than group I-2 occupancies in buildings less than three stories above grade plane of other than Group I-3, Class B interior finish for non-sprinklered building and Class C interior finish for sprinklered buildings shall be permitted in interior exit stairways and ramps.

Section 804 of the IBC regulates the floor finish of the building. Since the building has automatic sprinklers in accordance to NFPA 13 the floor finish is determined to be Class II per section 804.4.2's exception. The class of the floor finish is determined by NFPA 353.

Decorative materials in Groups A and R-1 of this building suspended from wall and ceiling shall meet propagation criteria of NFPA 701. Decorative materials and trims are regulated in section 806 of the IBC. Per 806.5, interior trims shall have a minimum class C flame spread. Interior floor wall base shall not be less than Class II.

The hotel's interior finishes meet proper finish material per this section.

Fire Resistive Summary

Construction of the Sheraton Hotel met IBC's prescriptive methods. The building is a high rise construction type I-A. The building used applicable exception to reduce the fire barrier rating per code due to the fact that it has sprinkler systems installed throughout the building.

Means of Egress

General Means of Egress Requirements

This section will talk about the general egress concept that consists of this specific project:

The Sheraton Hotel has four types of exit components; exit access, exit passageway, interior exit stairways, and exit discharges.

- Exit Access: *That portion of means of egress system that leads from any occupied portion of a building or structure to an exit.*
- Exit Passageway: *An exit component that is separated from other interior spaces of a building or structure by fire-resistance-rated construction and opening protective, and provides for a protected path of egress travel in a horizontal direction to an exit or to the exit discharge.*
- Interior Exit Stairways: *An exit component that serves to meet one or more means of egress design requirements, such as required number of exits or exits access travel to the exit discharge or public way.*
- Exit Discharge: *That portion of a means of egress system between the termination of an exit and a public way.*

The Sheraton Hotel has two (2) interior exit stairways that serves the basement level up to the upper floors where the residential areas are located. There are three additional interior stairways that serves the basement levels up to level four (4). All exit passageways and exit discharges from the building will be done on ground level.

The maximum exit access travel distance shall not exceed 250 feet per Table 1016.2 of the IBC with a common path of travel 75 feet per IBC Table 1014.3. These distances were using the most restrictive occupancy category for the applicable building under a sprinklered building. The Sheraton Hotel complies with the travel distances and common path of travel.

See Appendix B for marked drawing plans showing the exits and interior exit stairways.

Floor Occupancy Analysis

The following color code was used to identify type of occupancy for levels one (1) through four (4). Table 12 below shows the color code that is used to classify the floors. Chapter 3, Occupancy Classification, of the IBC 2012 was used to classify the floor plans.

Table 12: IBC classification color code

IBC 2012 Classification	
Space Designation	**Example Color Codes**
Assembly Group A-2	
Assembly Group A-3	
Business Group B	
Mercantile Group M	
Storage Group S-1	
Storage Group S-2	

See Appendix C for floor plan with the identified room color.

Occupancy Load

IBC table 1004.1.1 gives the maximum floor area allowance per occupant. Table 13 shows the occupant load by using table 1004.1.1 and the calculated area of the rooms using the floor plans for levels 1 to 4.

Table 13: Occupant load break down

Room	Area (ft^2)	Occupant Load Factor (ft^2/person)	Classification	Occupancy Load
Ground floor			**Sheet**	**A1.103**
Retail	1485	30	IBC 1004.1.2	50
Food and Bev. Storage	1750.2	300	IBC 1004.1.2	6
Human Resource	1000	100	IBC 1004.1.2	10
Receiving	396.75	100	IBC 1004.1.2	4
Gift Shop	834.25	30	IBC 1004.1.2	28
Locked Storage	340.75	300	IBC 1004.1.2	1
F&B Storage	2056.4	300	IBC 1004.1.2	7
Front Office	1050	100	IBC 1004.1.2	11
Kitchen	4500	200	IBC 1004.1.2	23
Restaurant	3543	15	IBC 1004.1.2	236
Pantry	300	300	IBC 1004.1.2	1
Bar	768	15	IBC 1004.1.2	51
Lounge	2352	15	IBC 1004.1.2	157
Total				583
2nd Floor			**Sheet**	**A1.104**
Junior Ballroom	14045	7	IBC 1004.1.2	2006

Room	Area (ft^2)	Occupant Load Factor (ft^2/person)	Classification	Occupancy Load
East Pre-Function	5870.4	15	IBC 1004.1.2	391
South Pre-Function	2038.5	15	IBC 1004.1.2	136
North Pre-Function	2595	15	IBC 1004.1.2	173
Terrance	3460	15	IBC 1004.1.2	231
Office/business center	1112.4	100	IBC 1004.1.2	11
Bev. Pantry	1394	300	IBC 1004.1.2	5
Banquet Meeting Storage	1928.16	300	IBC 1004.1.2	6
Tel. Rack room	72	300	IBC 1004.1.2	1
Banquet Plating/dish	6749.75	200	IBC 1004.1.2	34
Storage	2427.25	300	IBC 1004.1.2	8
Table Storage	520	300	IBC 1004.1.2	2
Food Set-Up	578.5	200	IBC 1004.1.2	3
Dish Washing			IBC 1004.1.2	
Glass	482	200	IBC 1004.1.2	2
Coffee	578.5	200	IBC 1004.1.2	3
Bar Set up	578.5	200	IBC 1004.1.2	3
Board Room A	964.25	15	IBC 1004.1.2	64
Meeting Room 1	2432	15	IBC 1004.1.2	162
Meeting Room 2	2588.75	15	IBC 1004.1.2	173
Meeting Room 3	1042	15	IBC 1004.1.2	69
Meeting Room 4	1248	15	IBC 1004.1.2	83
Meeting Room 5	3100	15	IBC 1004.1.2	207
Meeting Room 6	5557.5	15	IBC 1004.1.2	371
Meeting Room 7	2739	15	IBC 1004.1.2	183
Meeting Room 8	1222	15	IBC 1004.1.2	81
Meeting Room 9	1189	15	IBC 1004.1.2	79
Meeting Room 10	2887	15	IBC 1004.1.2	192
Meeting Room 11	2632	15	IBC 1004.1.2	175
Total				3287
3rd Floor			**Sheet**	**A1.105**
Main Ballroom	20354.4	7	IBC 1004.1.2	2908
East Pre-Function	2775.64	15	IBC 1004.1.2	185
South Pre-Function	5058	15	IBC 1004.1.2	337
West Pre-Function	1648	15	IBC 1004.1.2	110
Table Storage	520	300	IBC 1004.1.2	2
Food Set-Up	578.5	200	IBC 1004.1.2	3
Glass	482	200	IBC 1004.1.2	2
Coffee	578.5	200	IBC 1004.1.2	3
Bar Set up	578.5	200	IBC 1004.1.2	3
Executive Office	4857.4	100	IBC 1004.1.2	49

Room	Area (ft^2)	Occupant Load Factor (ft^2/person)	Classification	Occupancy Load
Board Room B	361	15	IBC 1004.1.2	24
Meeting Room 12	135.25	15	IBC 1004.1.2	9
Meeting Room 13	937.9	15	IBC 1004.1.2	63
Meeting Room 14	937.9	15	IBC 1004.1.2	63
Employee Dining Room	1439	15	IBC 1004.1.2	96
Work Room/Office/Host	3224	100	IBC 1004.1.2	32
Uniform Room	651	300	IBC 1004.1.2	2
South Mechanical Room	1389	300	IBC 1004.1.2	5
Total				1956
4th Floor			**Sheet**	**A1.106**
Pool	1030	50	IBC 1004.1.2	21
Pool Terrance	10224.5	15	IBC 1004.1.2	682
Outdoor Function	9283	7	IBC 1004.1.2	1326
Outdoor Pre-Function	401.25	15	IBC 1004.1.2	27
Gym	3722.7	50	IBC 1004.1.2	74
Boiler Room A	1573	300	IBC 1004.1.2	5
Boiler Room B	1685.4	300	IBC 1004.1.2	6
Mechanical Room	1438	300	IBC 1004.1.2	5
Storage 1	505.6	300	IBC 1004.1.2	2
Storage 2	1011.2	300	IBC 1004.1.2	3
Total				833

The second and third floor of the hotel has an occupant load modification, due to the unlikely event that the ball rooms and the pre-function areas to be filled at full capacity. The building official approved the implementation of the exception given in section 1004.1.2. The occupancy loads around the ballrooms on level two (2) and three (3) are to include the full load of the pre-function area plus the 1/3 the max occupancy of the ballrooms. The occupancy value in the ballroom is determined by using an occupancy load factor of 7 sq. ft. per person.

Egress Width, Stair Dimensions and Placement of Exits

Section 1005 means of egress sizing explains how to size stairway and exit doors. Section 1005.3.1 stairway is used to size the interior exit stairways and Section 1005.3.2 is used to size the doors and corridors. The Sheraton Hotel has sprinkler systems installed which means the capacity factor for the stairs and doors are less than what is stated in each section because it meets the exceptions. Table 14 shows the capacity factor that is used to calculate the minimum width of the stairs, doors and corridors used to egress on each floor. The capacity factor are used to calculate the egress doors width, however the door leaf must be a minimum of 32” in clear width and maximum of 48” clear width for a single leaf door per Section 1008.1.1.

Table 14: Minimum width needed for each floor per occupant load

Means of Egress	Capacity Factor
Interior Exit Stairway	0.2
Doorways	0.15

$$Stair\ Exit\ Capcity = Occupant\ Load * 0.2$$
$$Door\ Exit\ Capcity = Occupant\ Load * 0.15$$

Appendix D provides the occupant capacities of the exits for floor level 1 through 4.

Level 1 has a total exit capacity of 7120 persons.

Level 2 has an exit capacity of 3720 persons from the floor to the stairwells.

Level 3 has an exit capacity of 3360 persons from the floor to the stairwells.

Level 4 has an exit capacity of 2010 person from the floor to the stairwells. This does not include the maintenance stairwell located in the south corridor because the stairs main purpose is to provide access to the machine rooms.

Section 1005.7.1 also discusses encroachment into the required egress pathways. Doors when fully open cannot reduce the required width by more than 7 inches and doors at any position shall not reduce the required width by more than half the width of egress.

The exit doors, stairs, and corridors do comply with the occupant load and its prescribed minimum width for each floor. The quantity of exits also agrees with Section 1021.2.4. It states that three (3) exits shall be provided if the occupant load from 501 to 1000 person and four (4) exits shall be provided if there are more that 1000 occupants, which is the case for the level one (1) through level four (4). There is an encroachment issue on the main ballroom on level three (3) per Section 1005.7. The north doors that lead to the service corridors have doors that reduce the egress of the vestibule by more than half (55 % reduction). The recommendation is to increase the vestibule width in order for to comply with the encroachment section. The second recommendation is to not classify these doors as egress doors, which will not be any issue when the main ballroom is in service without its partition walls but will be a concern when the partition walls are used. If the second recommendation is used it is crucial to have less than 49 occupants when partition walls are set up for section B, E, and C within the main ballroom. Figure 2 shows the egress encroachment of the vestibule along the north service corridor.

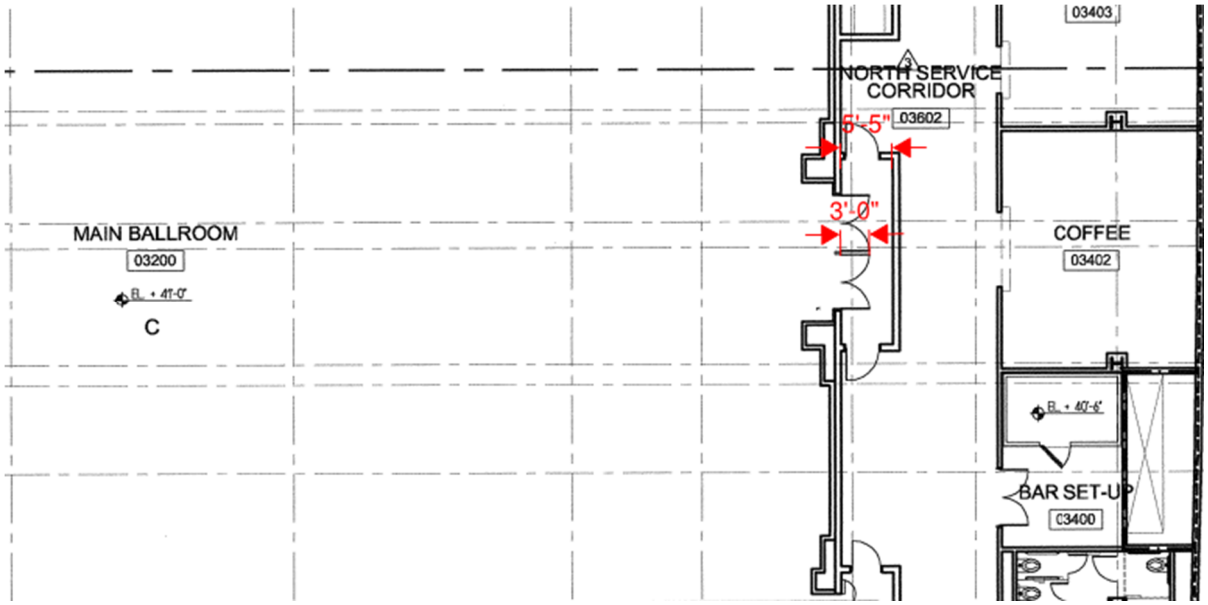


Figure 2: Main Ballroom vestibule encroachment issue

When two or more exits or exit access doorways are required in a building or service area the distance between the exits shall be no less than one half (1/2) the maximum diagonal distance of the building or the area to be served per section 1015.2.1 of the IBC. There are two exceptions to this code.

Exception 1 – Where interior exit stairways are interconnected by 1 hour fire resistance rated corridor conforming to requirements of section 1018, the required exit separation shall be measured along the shortest direct line of travel within the corridor.

Exception 2 – Where the building is equipped throughout with an automatic sprinkler system in accordance with Section 903.3.1.1 or 903.3.1.2, the separation distance of the exit door or exit access doorways shall not be less than one-third of the length of the maximum overall diagonal dimension of the area served.

The Sheraton hotel is able to use both exceptions, the corridors guiding occupants to stairs have the minimum fire rating in (exception 1) and the building is entirely sprinklered per IBC requirements (exception 2). Most of the building complies with this exit distance criteria except for the terrace on level two (2). The maximum diagonal distance is 73 feet 4 inches and the distance between exits is 22 feet and 8 inches. This separation distance falls short of the one third (1/3) minimum per 1021.2.4 exception 2. It is recommended to relocate the doors to meet the minimum separation distance per the IBC code. Figure 3 shows the dimension of the separation distance as well as the maximum diagonal distance of the terrace.

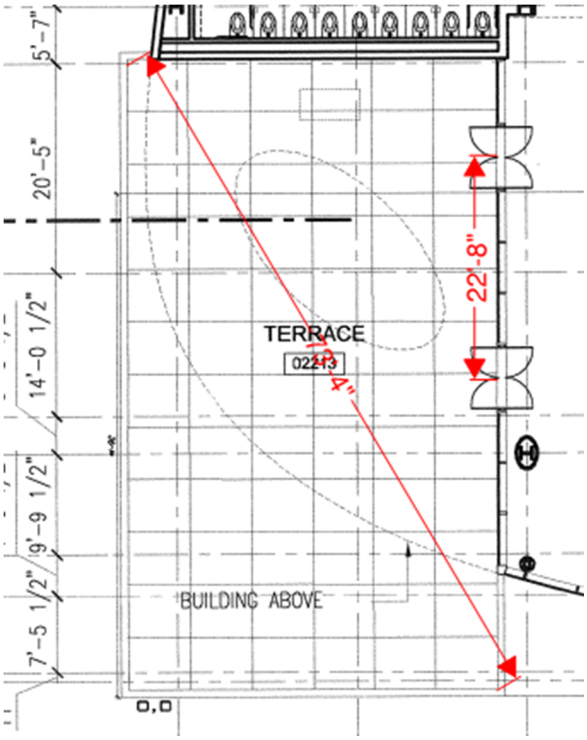


Figure 3: Level 2 Terrace measurement

Means of Egress Illumination and Exit Signs

Section 1006 states the illumination of the exit sign must not be less than 1 footcandle at the walking surface. The illumination of these sign must be lit even among power failure. The emergency power shall be provided for a minimum of 90 minutes.

Exit signs are required by IBC Section 1011. The section states that the sign shall be marked by any direction of travel and clearly indicate the direction of egress. The maximum distance between signs cannot exceed 100 feet. Plans for the locations of the exits signs were not provided for review.

Appendix E has suggestions and recommendation of possible locations of the exit signs.

Fire Resistance Rating

The required fire resistance along the stair ways for the Sheraton hotel is a 2 hour fire rating per Section 1009.3.1.2.

1009.3.1.2 Fire-resistance rating. Exit access stairway enclosure shall have a fire-resistance ration of not less than 2 hours where connecting four stories or more, and not less than 1 hour where connecting less than four stories. The number of stories connected by the exit access stairway enclosure shall include any basements, but not mezzanines. Exit access stairway enclosures shall have a fire resistance rating not less than the floor assembly penetrated, but not exceed 2 hours.

Interior finishes shall be made according to Section 803.9 the only two types of interior finishes are allowed in the Hotel. See Table 15 below for the detailed flame spread index and smoke develop index.

Table 15: Applicable interior wall and ceiling finish requirements by occupancy

Interior Finish	Type	Section	Flame Spread Index	Smoke Developed Index
All interior items	**B**	803.9	26-75	0-450
Storage	**C**	803.9	76-200	0-450

The exit corridors near the stairs will require a 2 hr. fire rating according to Section 707.3.10. The south corridor in the ground level which is also the exit passageway only needs a 1 hr. fire resistance according to section 1015.2.1 exception 1.

Pre-movement Behavior Response and Time Evacuation

The Sheraton hotel is located in an active area where there are sports arenas, concert halls, meeting room and various activities. It is assumed that 95% of the persons can move on their own. Table 16 below shows the main categories of each group in the hotel and its occupant alertness, occupant familiarity, and its occupant density.

Table 16: Proposed occupant alertness, familiarity, and density

Category	Occupant Alertness	Occupant Familiarity	Occupant Density
Assembly Group A-2	Awake	Unfamiliar	High
Assembly Group A-3	Awake	Unfamiliar	High
Business Group B	Awake	Familiar	Low
Mercantile Group M	Awake	Unfamiliar	Low
Storage Group S-1	Awake	Unfamiliar	Low
Storage Group S-2	Awake	Unfamiliar	Low

Table 17 below summarizes the expected pre-movement activities.

Table 17: Pre-movement activity assumption

Pre movement activities	Time (s)
Recognition Time	60
Response Time	180
Total	240

The data on Table 17 has been gathered from the evacuation drill studies and the delay of time study in the SFPE handbook (Proulx, 2008). For this report the evaluation is done for levels one (1) through four (4) during daytime when the ballrooms are most likely to be occupied. The time delay study that best suites this scenario is that of an evacuation of a midsize office building. In the reference, it is stated that the maximum pre-movement evacuation time is 4 minutes on midsize office buildings. The levels being evaluated are likely to be at maximum capacity during

daylight so it is assumed that the occupants will be alert and quick to react. The total pre movement time for this hotel will be a 4 minute (240 seconds) time period, which is the max pre-movement time of a midsize office building.

Timed Evacuation

The timed evacuation is be done by using a computer model. The model focuses on level one (1) through level four (4) of the building. A computer model is conducted without inputting the pre-movement parameter. The pre-movement time assumptions will be added at the end of the models egress time calculation.

Computer Based Evacuation

There are several computer based evacuation egress simulation models that are used to calculate the evacuation of a building. The program that will be used to evaluate the computer analysis egress is Pathfinder by Thunderhead Engineering.

The evacuation time shown in this report is only for level one (1) to level four (4) of the hotel. The occupant loads used in this model per accordance to the load capacity mentioned in the previous section and shown in the drawings in Appendix B.

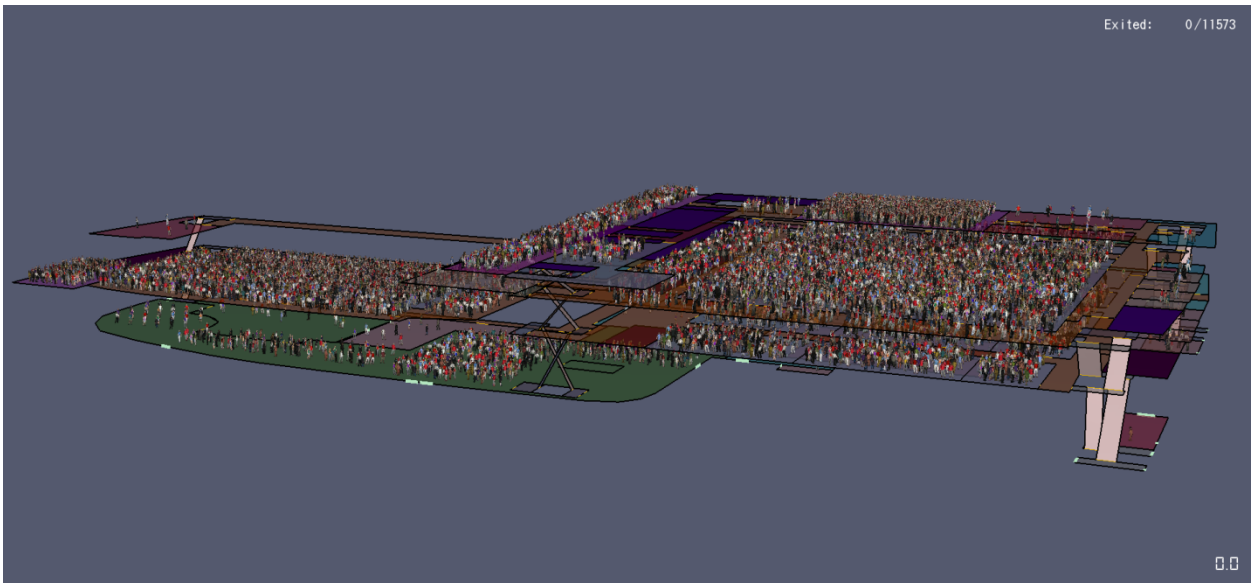


Figure 4: Sheraton Egress Model Start Time

The average travel speed of the occupants for this model is 3.9 ft/sec. The total evacuation time that was the results of this model is 20 minutes and 23 seconds for a full evacuation of the building.

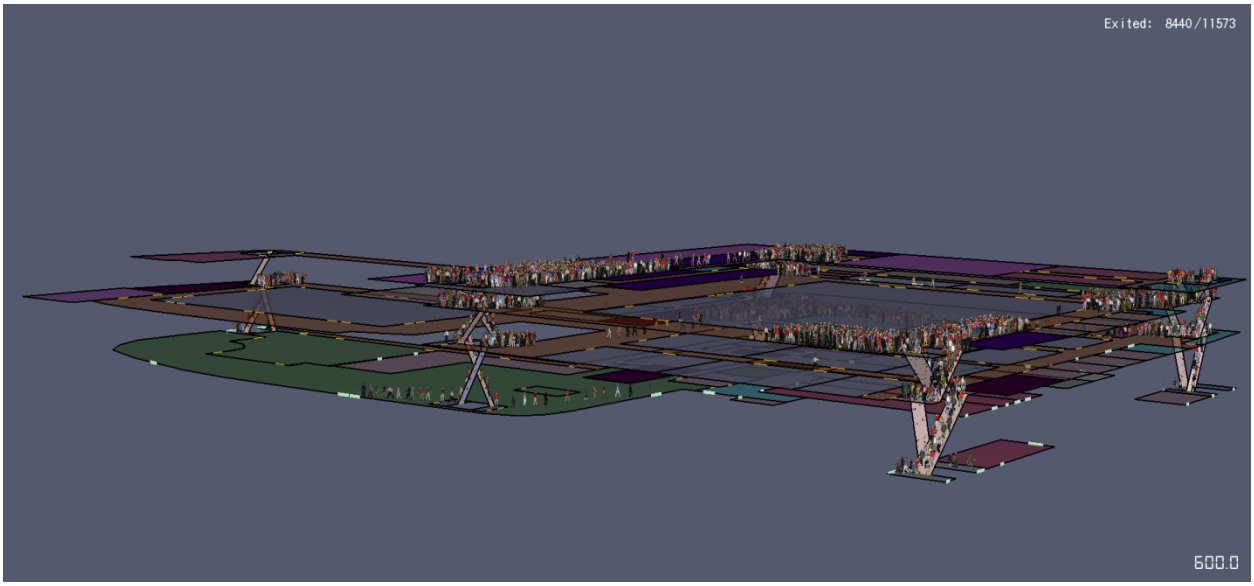


Figure 5: Sheraton Hotel Egress Model at 10 minutes

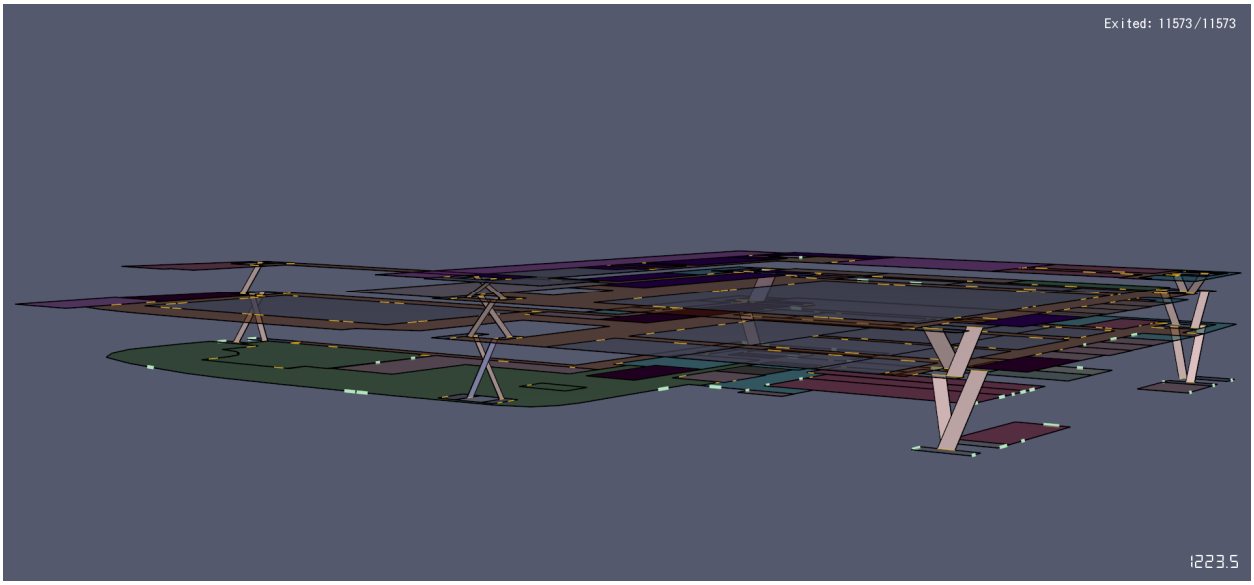


Figure 6: Sheraton Hotel Egress Model End of Egress

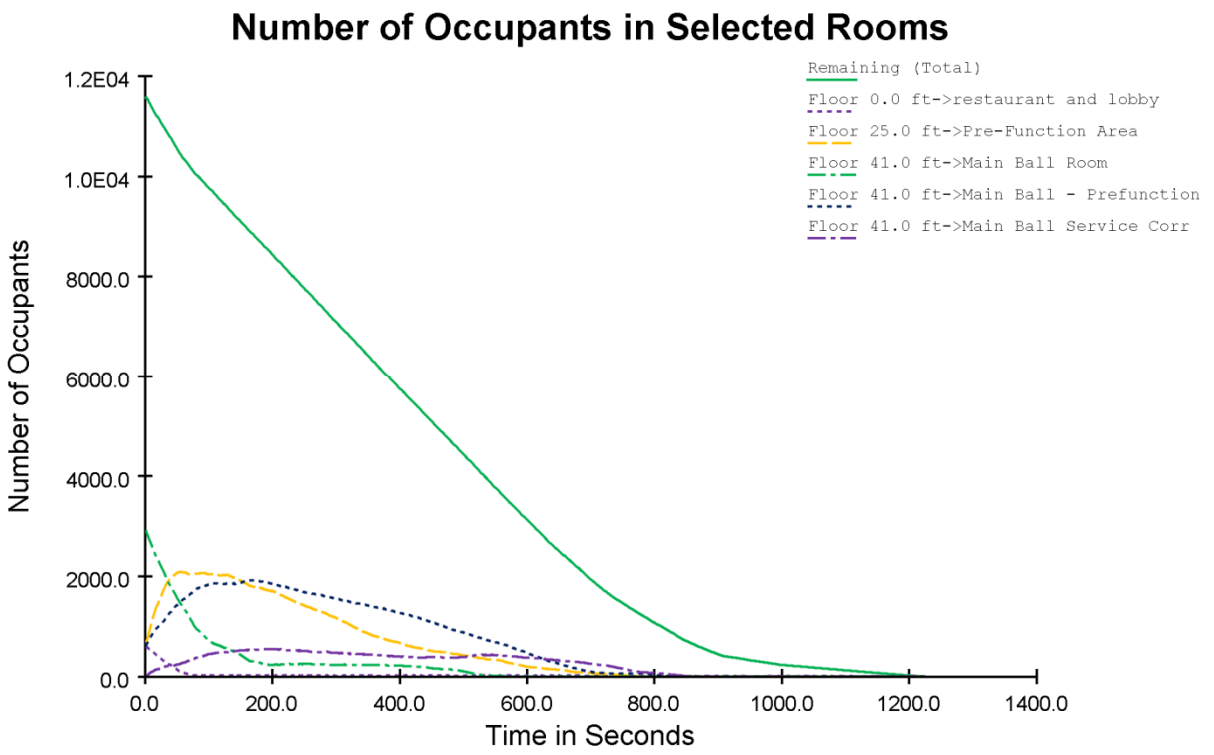


Figure 7: Sheraton Result Egress Time

When the pre-movement time is added the evacuation time required set egress time (RSET) is 24 minutes and 23 seconds.

Means of Egress Requirement Summary

The Sheraton hotel has met most of the egress requirement for the building. There are two rooms within the building that does not comply with the code. The terrace in room level two (2) and the main ball room on level three (3).

The terrace does not comply with the door width separation of the building. It is recommended that the doors be separated to meet the minimum separation distance in accordance with 1021.4.2 of the IBC. The main ballroom has doors that surpass the encroachment limit set by 1005.7 of the IBC. There are two recommendations, one is to extend the vestibule area so that the door swing complies with encroachment and the second recommendation is to not use the doors as egress doors. The second recommendation does come with occupant load restriction when the ballroom has its partition walls set up. When the ballroom partition walls are in use section areas B, C, and E of the ballroom must have less than 49 occupants in each section.

Using the Pathfinder computer model the total egress time for level one (1) to four (4) is 24 minutes and 23 seconds. The total egress time takes into account the pre-movement period taken from the SFPE Handbook of Fire Protection Engineering. The next section will discuss two performance based design analysis that focuses on the tenability of the area around the fire scenarios as occupants are egressing.

Performance Based Design Analysis

The Sheraton Hotel has various areas within the building to establish a fire scenario in order to conduct a performance based analysis. Four (4) fire scenarios were proposed to the AHJ, a kitchen fire in the restaurant, a workstation fire in the business units, a small couch fire in the main lobby reception area, and a tradeshow kiosk fire in the main ballroom. After discussing the possible fire scenarios with the AHJ, it was determined that the couch lobby fire and the tradeshow kiosk fire were the two fire scenarios to be used for the performance based analysis. The reason why the other fire scenarios were discarded is because the kitchen fire and the workstation fire do not involve a large percentage of the occupants within the. The objectives of the performance based design are discussed for each scenario in the following paragraphs.

The first fire scenario, couch lobby fire, is located on level one (1) in the reception/lobby area. This area of the hotel was chosen because there is a small atrium that exposes the pre-function area in level two to smoke in an event of a fire. Atriums typically through the IBC code are not allowed to have high fire loads on the ground level per Section 404 unless it has an approved fire suppression system in accordance to 903.3.1.1. Using the exception, the hotel is allowed to place upholstered couches, upholstered chairs, tables, and a bar on the ground floor of the atrium. Per IBC Section 404.3, the sprinkler systems must be installed throughout the building with an exception of the atrium level 2 roof due to the fact that the hotel has a 2 hour fire barrier. This atrium is only 2 stories so the hotel does not need to provide a smoke control system per the exception in Section 404.5 of the IBC. The enclosure of the atrium is met in Section 404.6 by providing a 2 hour horizontal assembly per Section 711. The objective of this fire performance is to verify tenability on level two (2) pre-function area while occupants are egressing. The tenability criteria will be discussed in the section below. The fire fuel in this scenario is a couch with heat release rates and soot values taken from CFAST example fire scenarios that are gathered from the test data done by Barbrauskas (Barbrauskas, Upholstered Furniture Room Fires - Measurements, Comparison with Furniture Calorimeter Data, and Flashover Predictions, 1984).

The second fire scenario is located in the main ballroom on level three (3). This area of the hotel was chosen because it is the largest room in the hotel capable of hosting a large number of persons. In this scenario, the fire will be located in a typical tradeshow event. Phoenix Fire Department requires that exhibits, all exhibit display construction, decoration material, and drapes be flame retardant. Documentation must be provided that materials entering tradeshows meet this requirement; otherwise, a field flame test based on NFPA 701 will be conducted on a 1 x 4 inch sample. Plywood less than ¼" must be flame retardant as well. This information can be found in the Fire and Life Safety Regulation for Exhibitor in the Phoenix Convention Center and Venues. For this project it is assumed that the Sheraton will follow the same guidelines. The fuel load for this scenario is a kiosk fire that does not fall into compliance of the regulation. It is assume that this Kiosk was rushed and that paper work and materials of the products do not necessarily match and non-compliant material is placed at the tradeshow. This fire will be placed along the middle of the room and will have 50 RTI quick response sprinklers to verify the activation time. The objective of the performance based analysis is to verify that tenability is maintained in this room while the occupants leave and to check if there is a possible flame spread concern to surrounding kiosks within the trade show. For this analysis, the other Kiosk

will be compliant with the flame retardant requirements set by the Phoenix Fire Department. The other kiosks will comply with the IBC Section 402.6.2, which requires the maximum heat release rate of a kiosk to be 100 kW when tested to UL 1975 standard. The ignition temperature for the compliant kiosks is 650°F, which is a standard ignition temperature for plywood and wood.

Performance Based Calculation Evaluating Tenability

Both scenarios for the performance based analysis rely on maintaining a tenability criteria as occupants are egressing. This section will describe the tenability criteria that shall be maintained throughout the egress time of the occupants. The table below is the established tenability criteria for both fire scenarios.

Table 18: Tenability Criteria

Temperature Limit	140 °F (60°C)
Visibility	50 ft. (15 m)
FED	0.5

The temperature criteria established is determined by reviewing data of test done when person come in contact from hot gases while being naked. The test results showed that when gas temperature reach 250°F (121°C) humans experience heat stroke and skin burns (ASHRAE, Handbook of Smoke Control Engineering). Looking at the graph provided in the data having a temperature range of 140°F (60°C) will allow an occupant to be under that exposure for a minimum of 60 minutes. This study is done when the occupants are exposed to the hot gases while being naked. Presence of clothes is considered beneficial as temperature increase, therefore this temperature limit is considered conservative per the Handbook of Smoke Control Engineering.

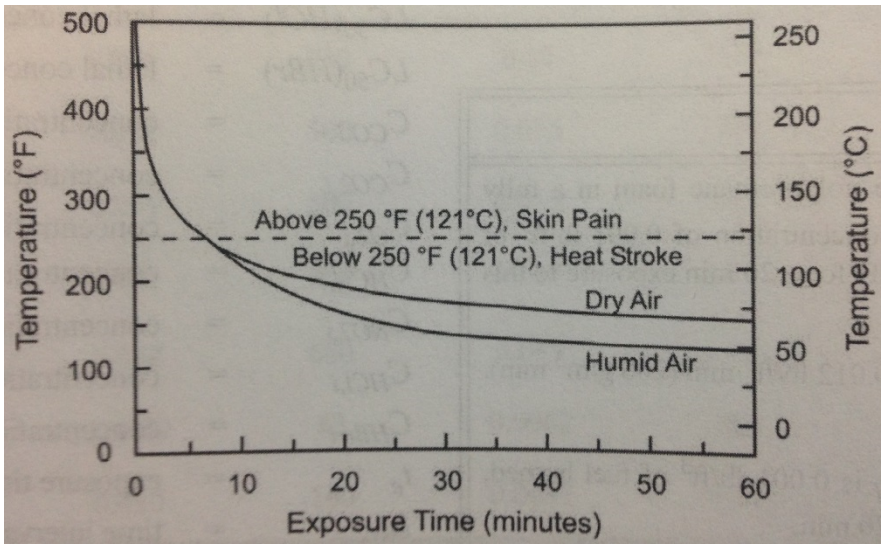


Figure 8: Heat tolerance for humans at rest, naked, with low air movement, Figure 6.1 of the Handbook of Smoke Control Engineering

The visibility tenability was determined by the dividing the exit signs maximum distance, 100 ft. (30 m) in half. Since this Sheraton Hotel has a large floorplan it is considered conservative to use a 50 ft (15 m) visibility criterion rather than the standard 32 ft. (10 meter) criterion.
The Fractional Effective Dose (FED) is used to evaluate fatalities due to toxicity. An FED value of 1 indicates a fatality. A value of 0.5 indicates a conservative incapacitated dose, ASHRAE's Handbook of Smoke Control Engineering. For the tenability criteria a value of 0.5 was chosen (Klote, A., Turnbull, Kashef, & Ferreira, 2012). The following Equation 1 will be used to calculate the FED value, taken from ASHRAE Handbook of Smoke Control Engineering.

$$FED_{max} = \frac{Kt}{2.303\delta_m S_c LCt_{50}}$$

Equation 1: FED Calculation

Where:
K = Proportionality constant (3 or 8)
t = Exposure time (min)
δ_m = Mass Optical Density (SF/lb or sm/g)
S_c = Visibility criterion (ft or m)
LCt_{50} = Lethal exposure dose from test data, (lb*min/cu. ft or g*min/cu. m.)

Performance Based Design Scenarios

There are two scenarios proposed to the AHJ for the Sheraton Hotel. Scenario 1 is a sofa fire in the lobby of the hotel. Scenario 2 is a kiosk fire in the main ballroom of the hotel. The following section will illustrate the location of the fires as well as the layout of the fire scenario with the results and conclusions.

The sofa fire in the first scenario is located on the ground floor in between the lounge and main reception area. The first and second levels are connected through an atrium. This structural design between these floors allows smoke to enter the pre-function area of the second floor of the building. As discussed in the previous section, the objective is to verify that the occupants in the pre-function area have enough time to safely egress the area. Figure 9 below will show the location of the fire and the setup of the FDS model.

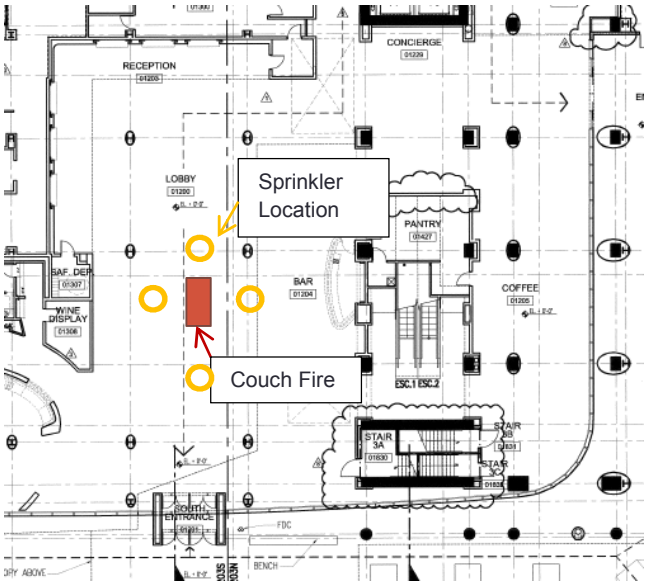


Figure 9: Fire scenario 1 location

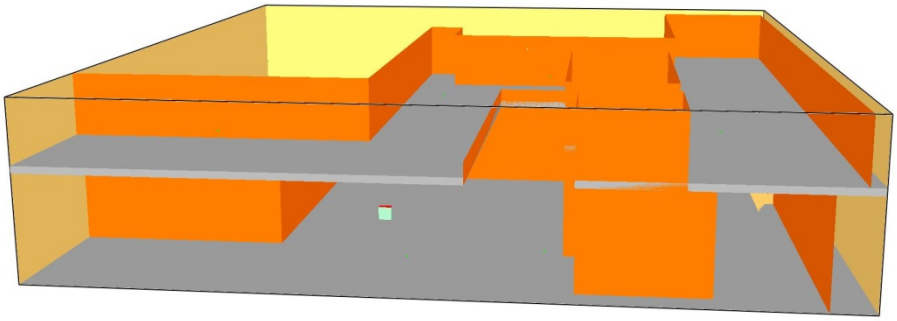


Figure 10: FDS setup of fire scenario 1

The upholstered sofa fire heat release rate (HHR) and soot data points used for the sofa fire is gathered from the National Institute of Standards and Technology (NIST) program, CFAST. The CFAST data inputs are used because it matches the expected heat release rate from Barbrauska's article for upholstered furniture room fires. (Barbrauskas, Upholstered Furniture Room Fires - Measurements, Comparison with Furniture Calorimeter Data, and Flashover Predictions, 1984). Figure 11 below is the CFAST curve with the time and HRR values that show the sofas' peak HRR at 3447 kW at 400 seconds with a soot yield of 0.129.

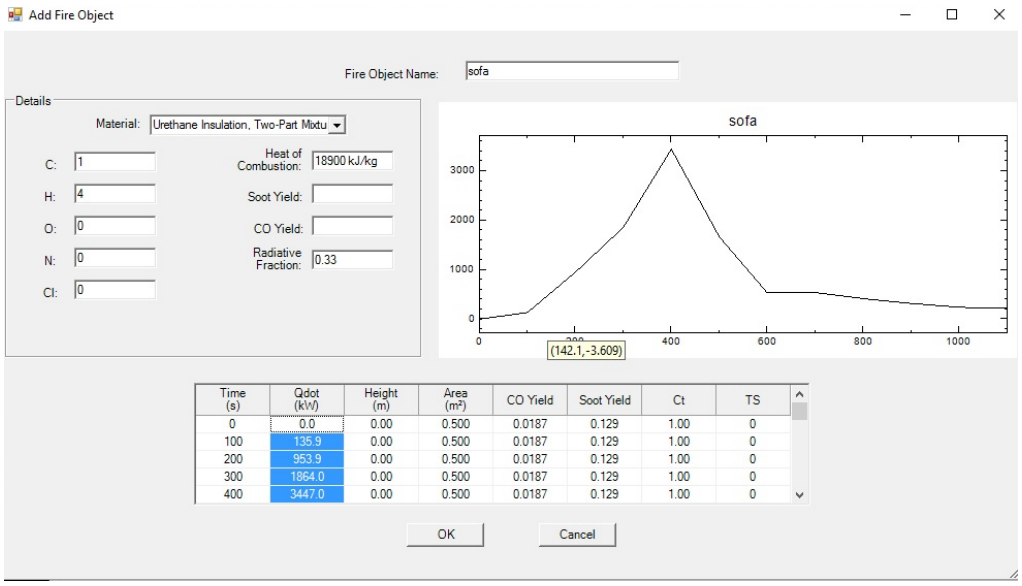


Figure 11: Fire Scenario 1 HRR sofa from CFAST

Table 19 shows the heat release rate input with the CO Yield and soot yield of the sofa that is used in the Fire Dynamic Simulator (FDS) model by NIST.

Table 19: Sofa HRR input data

SOFA HRR				
Time (s)	Qdot (kW)	Area (m^2)	CO Yield	Soot Yield
0	0	0.5	0.0187	0.129
100	135.9	0.5	0.0187	0.129
200	953.9	0.5	0.0187	0.129
300	1864	0.5	0.0187	0.129
400	3447	0.5	0.0187	0.129
500	1667	0.5	0.0187	0.129
600	531.7	0.5	0.0187	0.129
700	539.3	0.5	0.0187	0.129
800	415.9	0.5	0.0187	0.129
900	317.4	0.5	0.0187	0.129
1000	240.8	0.5	0.0187	0.129
1100	216.6	0.5	0.0187	0.129

The FDS input file will model sprinkler activation. The sprinklers are set 15 feet apart from one another to meet the maximum 225 ft^2 coverage area of a light hazard sprinkler systems per NFPA 13. The sprinklers have an RTI value of 50 and an activation temperature of 155°F (68°C). The egress time for the pre-function area on level two (2) is 800 seconds (See Figure 7 in the previous section). This is the time that tenability will need to be maintained for this scenario.

Running the FDS scenario it was determined the sprinkler was activated at 328 seconds just when the HRR of the sofa fire is 2296 kW. The sprinkler activated 72 seconds before the sofa's peak heat release rate. The sprinkler activation has enough time to wet the surrounding fuel loads and is assumed the fire will not spread any further throughout the main lobby. The couch

was left to continue to burn without any sprinkler suppression effects. The graph below shows the HRR output of the sofa fire with the point of wet sprinkler system activation shown.

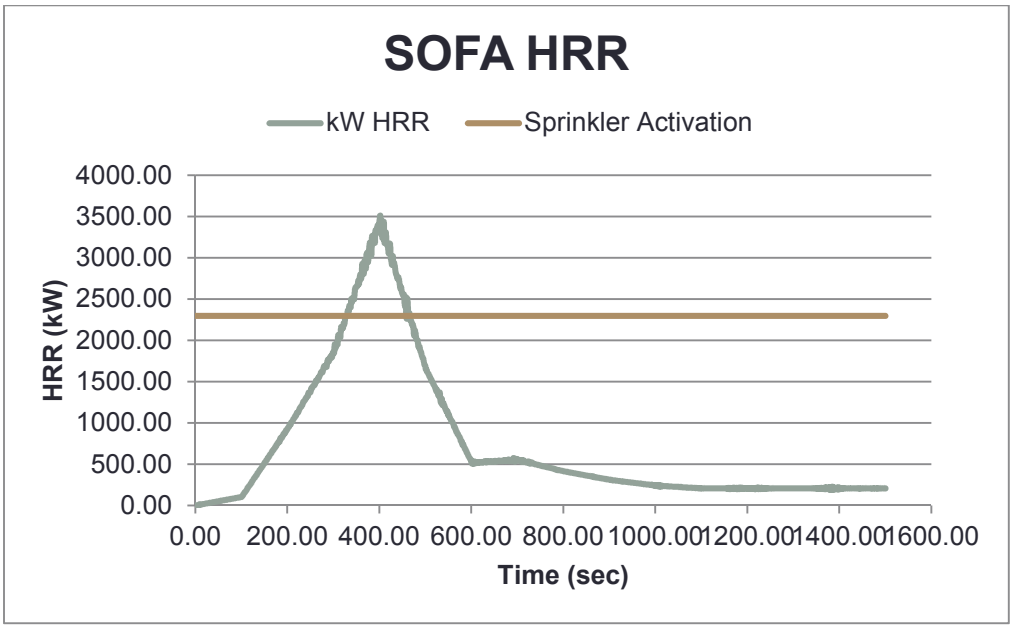


Figure 12: HRR output of the sofa with sprinkler detection marking

The temperature tenability at the egress time (800 seconds) was maintained. Below is the image of temperature slice file of the scenario. The pre-function room temperature never increased over 98.6°F (37°C).

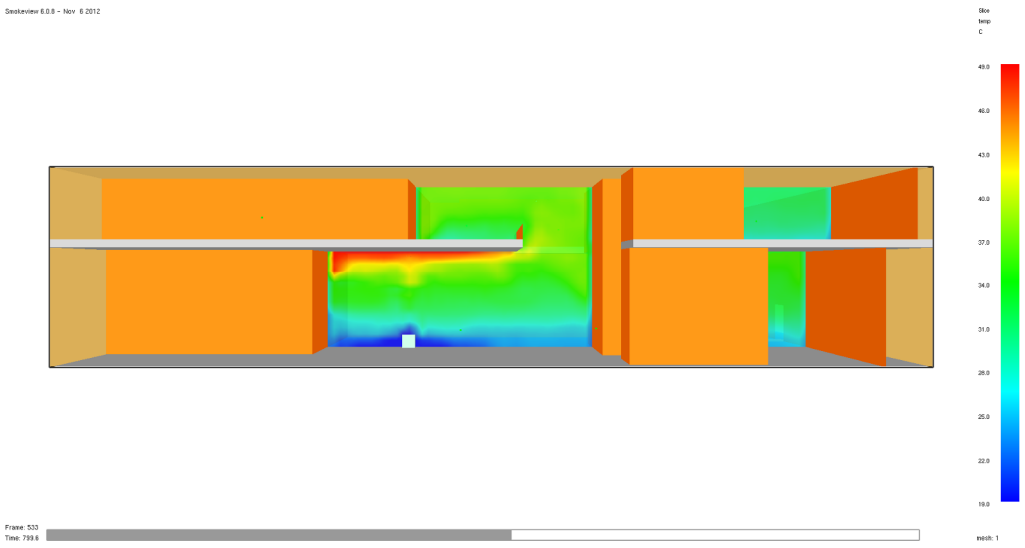


Figure 13: Temperature slice file at 800 second for scenario 1

Visibility for the sofa scenario was not reached at the 800 seconds. The visibility is at 1 meter, which means that the occupants in the pre-function area will not be able to find their way to an exit. The visibility tenability of (15 m) is reached at the 297 seconds mark. See the slice file in Figure 14 below.

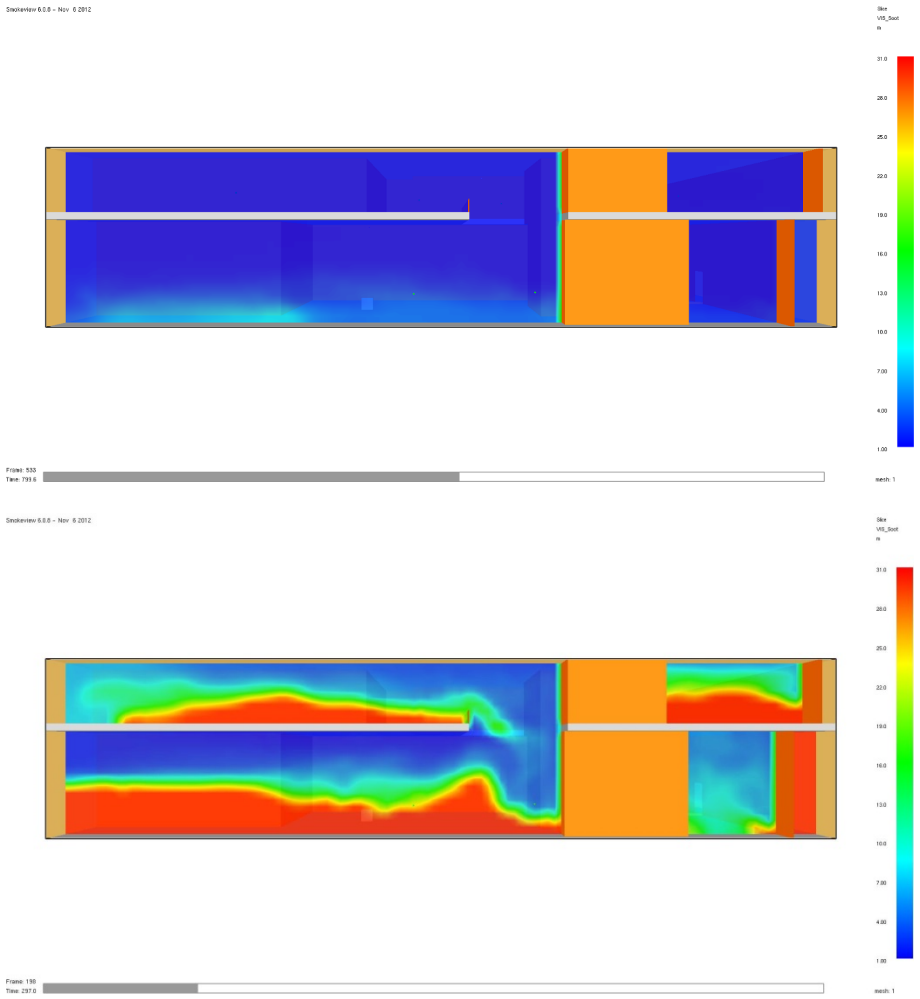


Figure 14: Visibility slice file for fire scenario 1 (top is the visibility at 800 seconds, bottom is visibility reach at 297 seconds)

The FED values are calculated from Equation 1. The proportionality constant used in this scenario is 8 because the hotel has illuminated signs placed in the building. The exposure time that will be used is 800 seconds. This is a conservative value because the occupants evacuating will not be exposed to the fire scenario the full 800 seconds. Mass optical density used in Equation 1 is 1600 ft^2/lbs (0.33 m^2/g). This value is the mass optical density of polyurethane foam. The lethal exposure dose is used from polyurethane foam 0.012 lb/ft^3*min (200 g*min/m^3). At the 800 second of the fire scenario the visibility is at 1 meter, the FED value at the 1 meter is 0.7. The value exceeds the FED criteria but still in below the fatal dose.

In conclusion the current set up for the building will not be able to allow the occupants to egress the pre-function area if there is a couch fire on the first level. The recommendation is to provide a glass wall to form a smoke partition per the exception rule in Section 404.6 of the IBC. The glass wall must have sprinkler systems on both sides and 4 inches and 12 inches away from the glass at 6 feet intervals. A smoke control system is costly and will not be feasible because real estate on levels three (3) and four (4) will have to be used in order for an exhaust system to

work. Natural ventilation is not feasible because there is just access to one side of the building and if the wind is in the opposite direction during a fire it could make the situation worse.

The input fire criteria can be found in the Appendix F.

The second fire scenario is located on the third level and in the main ballroom. The fire load is a kiosk fire in a trade show. As discussed in the previous section the goal is to analyze this scenario to verify that the occupants have enough time to evacuate as well as to check if the flame propagation of the kiosk is a risk to the main ballroom.

The main ballroom has a two (2) hour fire and smoke barrier wall. For this performance based analysis, the egress time of this scenario will only concern the evacuation of the main ballroom to the pre-function area because the 2-hour rated wall will provide enough safety for the occupants to evacuate in a safe manner. The fire will be placed in the middle and will have a burning cross sectional area of 5.38 ft^2 (0.5 m^2). There will be three (3) kiosks with similar size set three (3) feet apart and a larger kiosk set six (6) feet across the main walking pathway of the tradeshow. Other kiosks will be modeled to represent area taken up by the tradeshow event. For this scenario, the north doors of the main ballroom will not be considered as egress doors per egress encroachment issues discussed in the previous section. Figure 15 below will give an overview of the main ballroom fire scenario.

Sprinkler activation points are located around the kiosk fire. The sprinklers are set 15 feet apart from one another to meet the maximum 225 ft^2 coverage area of light hazard sprinkler systems per NFPA 13. The sprinklers have an RTI value of 50 and an activation temperature of 155°F (68°C). Sprinklers are modeled to verify when the wetting of the surrounding areas commences.

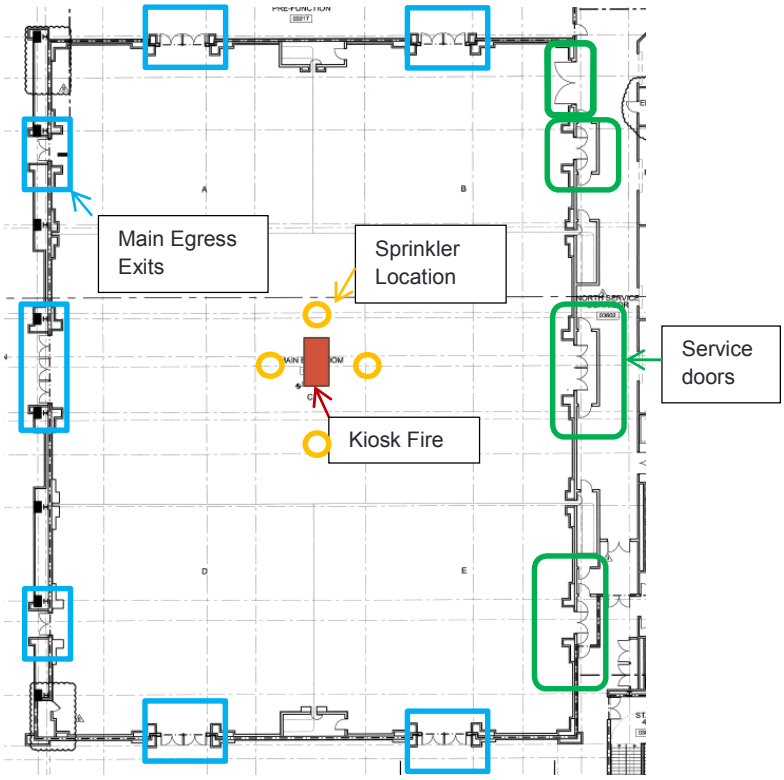


Figure 15: Fire Scenario 2 - Kiosk Fire

The egress time calculated on the Pathfinder model in the previous section was done with a maximum occupant load in an empty ballroom. Unlike scenario 1 a new egress time will have to be calculated taking into account the kiosk area within the ballroom service area. This change reduces the egress time from 500 seconds (see Figure 5) to 94 seconds. The new occupancy load is 2416 persons. This new occupancy is calculated by using an occupant load factor of 7 square feet per persons. Below are Figure 17, Figure 18, and Figure 19 from the pathfinder results as well as the egress graph.

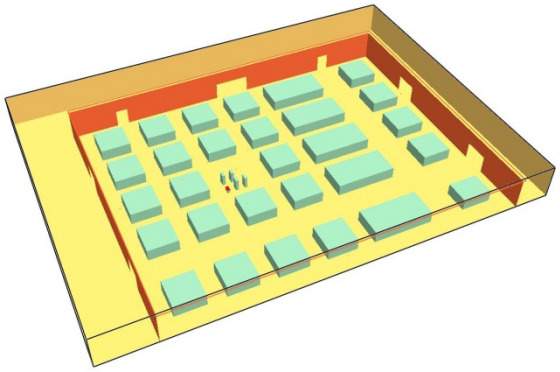


Figure 16: FDS set up view point from the service wall corridor

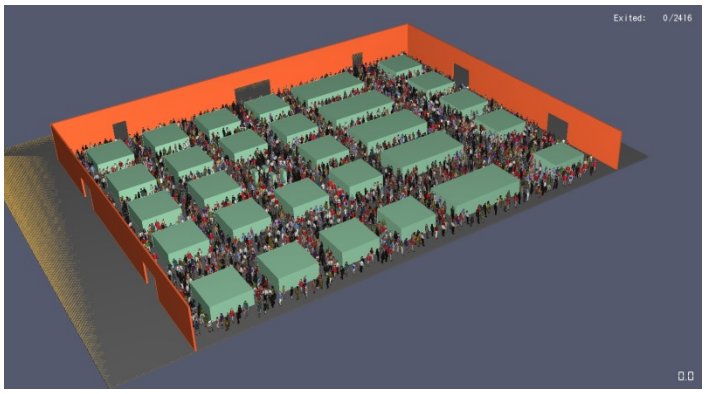


Figure 17: Main Ballroom start time of egress

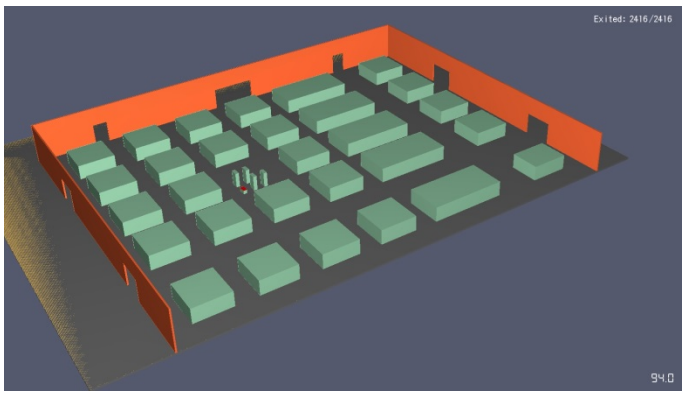


Figure 18: Main Ballroom 94 sec time of egress

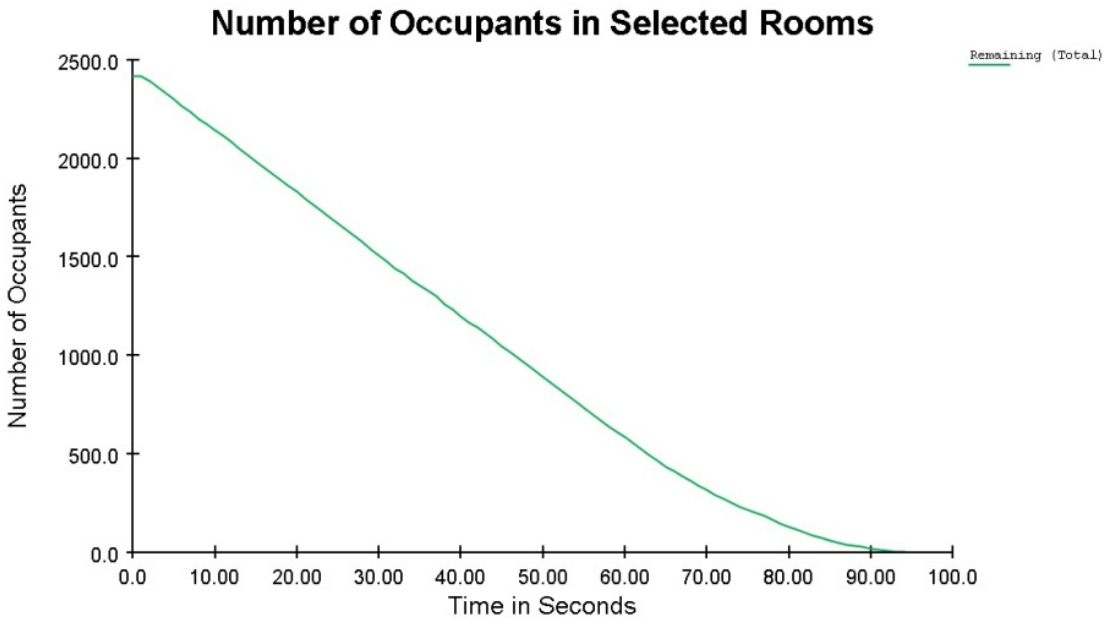


Figure 19: Main Ballroom egress graph

This is the time that tenability will need to be maintained for this scenario.

The kiosk fire HRR data is gathered from NIST program CFAST. Using their HRR rate curve and inputting the values into CFAST. Figure 20 below shows the CFAST heat release and soot values for the kiosk fire. NIST/CFAST heat release rate curve matches the expected curve and soot values from the SFPE handbook chapter on heat release rates (Barbrauskas, Heat Release Rates, 2008). The peak HRR rate for the kiosk fire is 1750 kW at 1230 seconds with a soot yield of 0.015.

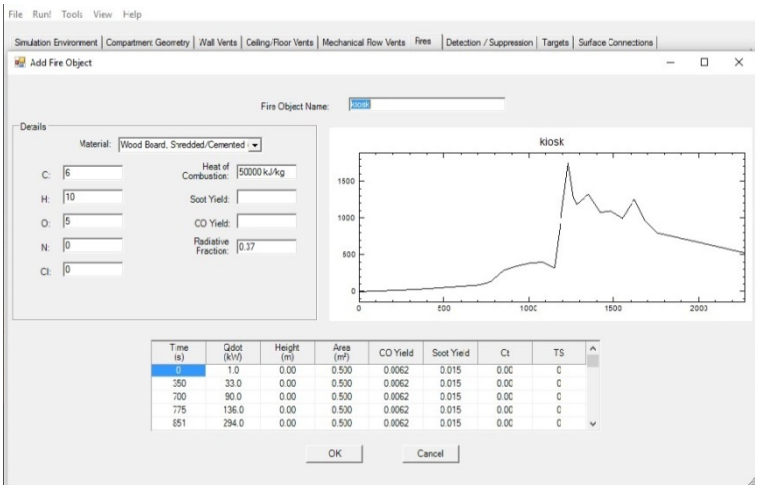


Figure 20: CFAST Kiosk fire HRR curve

Table 20: Kiosk HHR input data from CFAST

Kiosk HRR				
Time (s)	Qdot (kW)	Area (m^2)	CO Yield	Soot Yield
0	1	0.5	0.0062	0.015
350	33	0.5	0.0062	0.015
700	90	0.5	0.0062	0.015
775	136	0.5	0.0062	0.015
851	294	0.5	0.0062	0.015
927	348	0.5	0.0062	0.015
1000	387	0.5	0.0062	0.015
1080	403	0.5	0.0062	0.015
1150	323	0.5	0.0062	0.015
1230	1750	0.5	0.0062	0.015
1260	1290	0.5	0.0062	0.015
1280	1190	0.5	0.0062	0.015
1350	1330	0.5	0.0062	0.015
1420	1080	0.5	0.0062	0.015
1480	1100	0.5	0.0062	0.015
1550	1000	0.5	0.0062	0.015
1620	1260	0.5	0.0062	0.015
1680	977	0.5	0.0062	0.015
1750	805	0.5	0.0062	0.015
2270	529	0.5	0.0062	0.015

The model is set up so that once the surrounding kiosk reaches 650°F (343°C), the kiosk will catch on fire and start to release heat. There are two kiosks that are three feet from the fire and two kiosks that are six feet apart across the aisle from the main fire. As discussed in the previous section, the maximum heat release rate that the other kiosk will release is 100 kW per

IBC requirements of kiosk, Section 402.11. As discussed in the previous section, assume that other kiosks are compliant with the Phoenix Fire Department requirements for the kiosks to be flame retardant.

Running the FDS scenario it was determined the sprinkler was activated at 1181 seconds. The Heat release rate of the kiosk fire is at 400 kW. The sprinkler activation happens 55 seconds before the kiosk peak heat release rate occurs. The Figure 21 below shows the HRR output of the kiosk fire. The graph also shows the activation point of the sprinkler system.

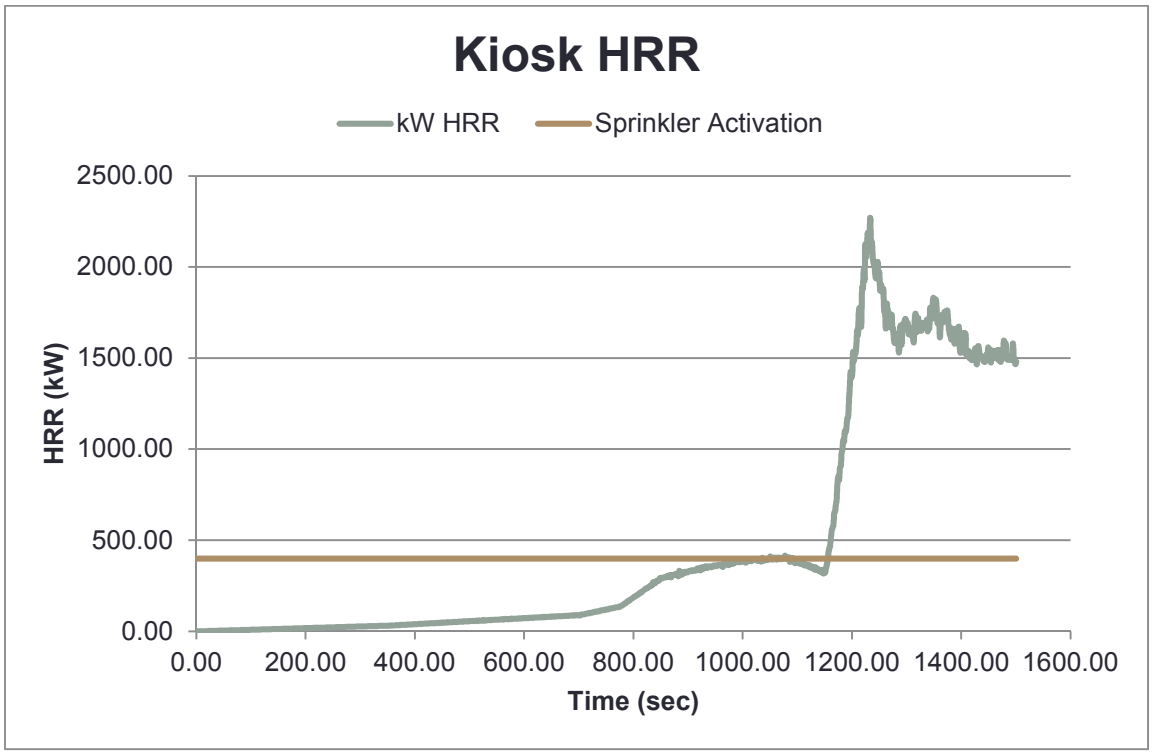


Figure 21: HRR output on FDS

The heat release rate output of the model is larger than the input shown in Figure 20; this is because all the neighboring kiosks catch fire at the 1255 second mark, which is 74 seconds after the sprinkler activation time. It is assumed that this is enough time for the sprinkler system to contain the fire and cool down the surrounding kiosk before ignition occurs on surrounding kiosks.

The temperature tenability criteria at the egress time (94 seconds) is maintained. Below is the image of temperature slice file of the scenario. The room temperature never increased over 68° (20 °C) at the 94 second mark. Blue indicates the temperature range to be at 68°F (20°C) in Figure 22.

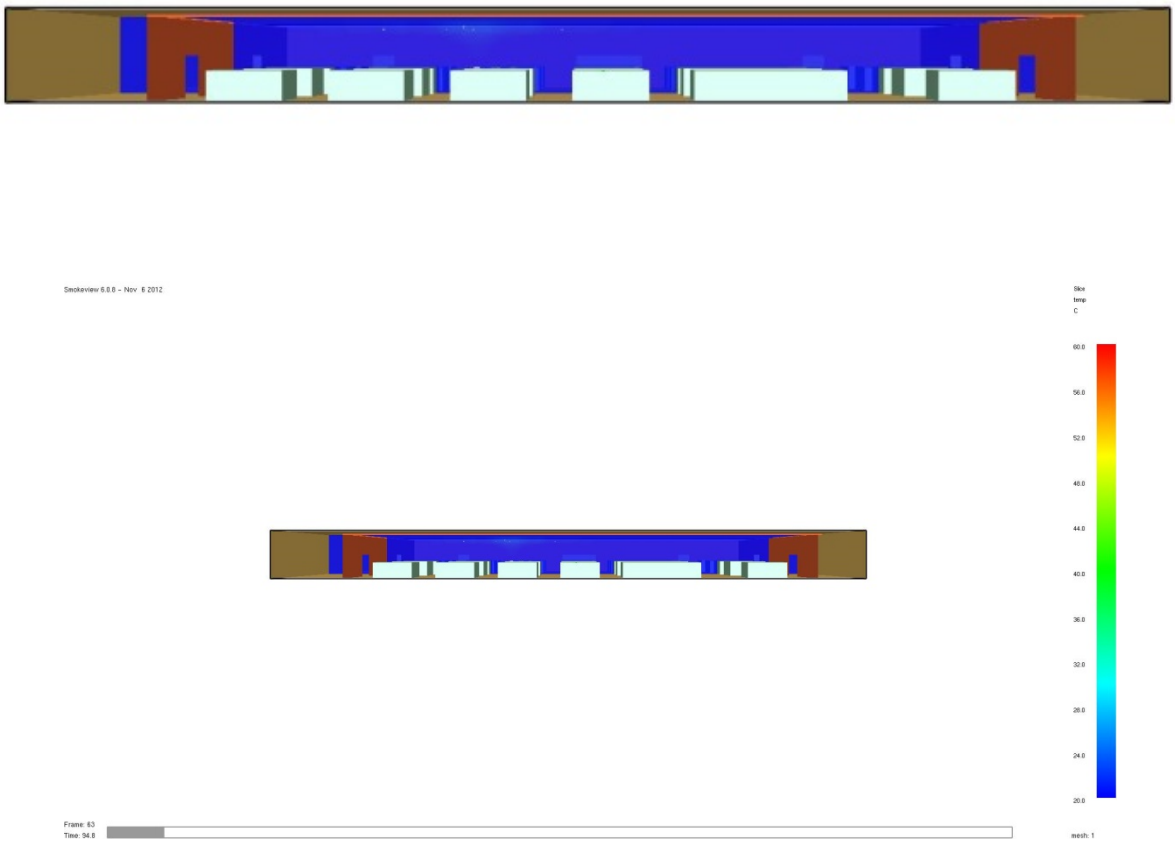


Figure 22: Temperature slice at 94 seconds for scenario 2

The visibility tenability for the kiosk scenario is reached at the 94 seconds mark when all the occupants have left the room. The visibility is maintained at 30 meter during the egress time. The red coloring on the slice file shows a 30 meter visibility range.

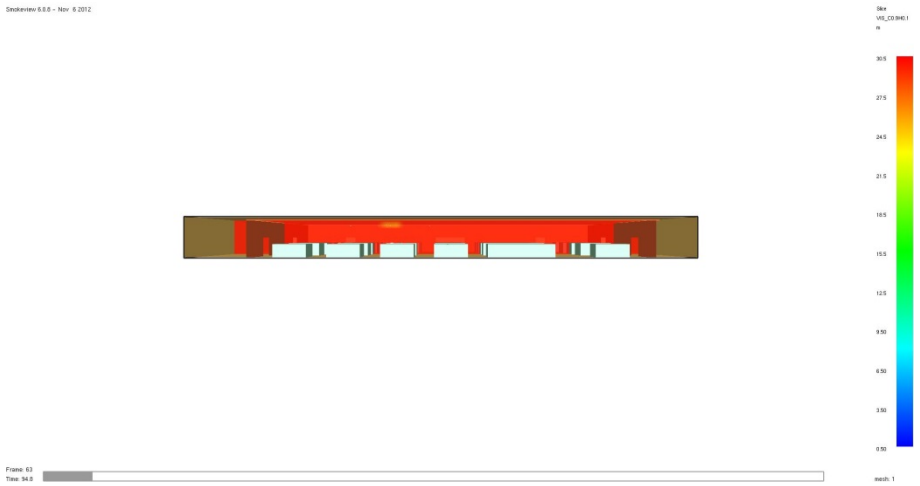


Figure 23: Slice visibility for fire scenario 2 kiosk fire

The FED values are calculated from Equation 1. The proportionality constant used in this scenario is 8 because the hotel has illuminated signs placed in the building. The exposure time that will be used is 94 seconds. This is a conservative value because the occupants evacuating will not be exposed to the fire scenario the full 94 seconds. Mass optical density used in equation 1 is 1400 ft^2/lb (0.29 m^2/g). This value is the mass optical density of plywood. The lethal exposure dose is used from cellulosic 0.047 lb/ft^3*min (400 g/m^3*min). Values are taken from the Handbook of Smoke Control Engineering. The calculated FED value is 0.002 and meets the criteria of less than 0.5 value.

The main ballroom meets the objective of this performance based design. It is able to maintain tenability criteria while occupants are egressing and it shows that flame spread of the kiosk fires will not happened. There is no recommendation necessary for this scenario.

The input fire criteria can be found in the Appendix F.

Performance Based Design Analysis Summary

In the first scenario, the couch lobby fire, the objectives of maintaining the tenability criteria (15 meters of visibility, temperature range of 60°C, and a FED value of 0.5) for the pre-function on level two (2) was not met during the egress time of the occupants. Visibility fell to 1 meter and the FED level was at 0.7. It is recommended to add a glass wall partition per Section 404.6 of the IBC code. An exhaust system and natural ventilation will not be feasible to install in this building. Level 3 and 4 have established areas that are used and will not be accessible to install an exhaust system. Natural ventilation will not work because there is only one wall that has access outside of the building. Under extreme wind condition this will make the scenario worst. Having a glass wall will allow the occupants in the pre-function area to evacuate without any visibility or toxicity concerns. The second fire scenario, the kiosk fire, in the main ballroom met the required objective. It met the tenability requirements and fire spread of the kiosk is not be an issue.

Fire Protection / Life-Safety Systems

Fire Suppression Systems

The Sheraton Hotel in downtown Phoenix, Arizona area has existing automatic sprinkler systems. A wet system is installed throughout the hotel. Since Phoenix, Arizona does not experience cold weather for a prolonged period of time there is no need for dry pipe systems.

Water Supply

The water supply available information has been provided by the city of Phoenix and show in Table 21.

Table 21: Water supply for the hotel

Static Pressure	80 psi
Residual Pressure	72 psi
Flow	6135 gpm

The underground piping of the building has 4 inch outlets that come from the city main streets.

Automatic Fire Sprinkler, Standpipe, and Fire Pump Systems

The sprinkler hazard classification of the Hotel is shown in Table 22 below.

Table 22: Sprinkler hazard classification

Level 1 Classification and Total Area	
17,255 sf	Ord. Hazard. Group I
3,120 sf	Light Hazard
Level 2 Classification and Total Area	
13,441 sf	Ord. Hazard. Group I
59,180 sf	Light Hazard
Level 3 Classification and Total Area	
42,307 sf	Light Hazard
2,160 sf	Ord. Hazard. Group I
2,040 sf	Ord. Hazard. Group II
Level 4 Classification and Total Area	
24,662 sf	Light Hazard
6,213 sf	Ord. Hazard. Group II
Level 5 to 31 Classification and Total Area (Typical Floor)	
18,014 sf	Light Hazard

Ground Floor through the Fourth Floor:

The sprinkler system for level one (1) to level four (4) varies through the hotel rooms depending on how the rooms are used and occupied. Ordinary Hazard Group I with requires 0.15 gpm/ft^2 fill density at 1500 sq. ft. area coverage. For Ordinary hazard II a 0.2 gpm/ft^2 is required at a 1500 sq. ft. coverage area and for Light hazard a 0.10 gpm/ft^2 density is required at 1500 sq. ft. area coverage. These parameters can be found in NFPA 13 standard figure 11.2.3.1.1

Fifth Floor through 31st Floor:

The sprinkler system for the ground from level five (5) to level 31 has the Light Hazard group at fill density of 0.10 gpm / ft^2 at 1500 sq. ft. The standpipe riser has a flow control system on each level to prevent over pressurization of the piping and sprinkler head in this high rise building.

Sprinklers recommended using for the light hazard occupancy areas are quick response sprinklers per NFPA 13 section 8.3.3.1. A typical K factor for these types of sprinklers is a 5.6 K-factor.

The Standpipe for this system will be a 4" standpipe in conformance with the requirements of NFPA 14. The wet stand pipe is installed on the east street facing 3rd street. It is considered to be a Class I standpipe. Minimum flow rate for the hydraulic stand pipe shall be 500 gpm. Minimum residual pressure on 100 psi is required at the outlet most remote 2.5 in hose connection per section 7.8.1 of NFPA 14. The sprinkler layout was not provided to review and hydraulic calculation will on the standpipe with the requirement that it needs 100 psi at the 31st floor. Due to the lack of fire sprinkler layout design to evaluate it was determined to use the values of the standpipe requirement which will give us a conservative value for the pressure and flow of the sprinkler systems.

Table 23: Standpipe Hydraulic Calculation

Project name:			Sheraton Hotel Downtown Phoenix											Date:	4/20/2016	
Step No.	Nozzle Ident and Location		Flow in gpm		Pipe size	Pipe Fittings and Devices	Equivalent Pipe Length		Friction loss (psi/ft)		Pressure Summary		Normal Pressure		Notes	
			q				L		C=		Pt	100.0	Pt		k=	
q	1	Top of			4		F				Pe		Pv			q = k * (Pt)^1/2
		Stand	Q	500.0			T		pf		Pf		Pn		Pt=	
			q				L	320	C=	120	Pt		Pt		k=	
					4		F				Pe	138.6	Pv			
			Q				T		pf		Pf		Pn		Pe=	138.56
			q				L		C=		Pt	238.6	Pt		k=	
	1	To					F				Pe		Pv			
		Pump	Q				T		pf		Pf		Pn			

Table 23 results are that the minimum pressure and flow requirements are 239 psi with a flow of 500 gpm in order for the automatic sprinklered system to work properly. This means that a fire pump that add 169 psi pressure while still able to flow 500 gpm of water is needed. Pressure of

the piping will be regulated at each floor using a pressure regulating valve at each floor. Below is the hydraulic graph with city supply, pump supply, and combination plots.

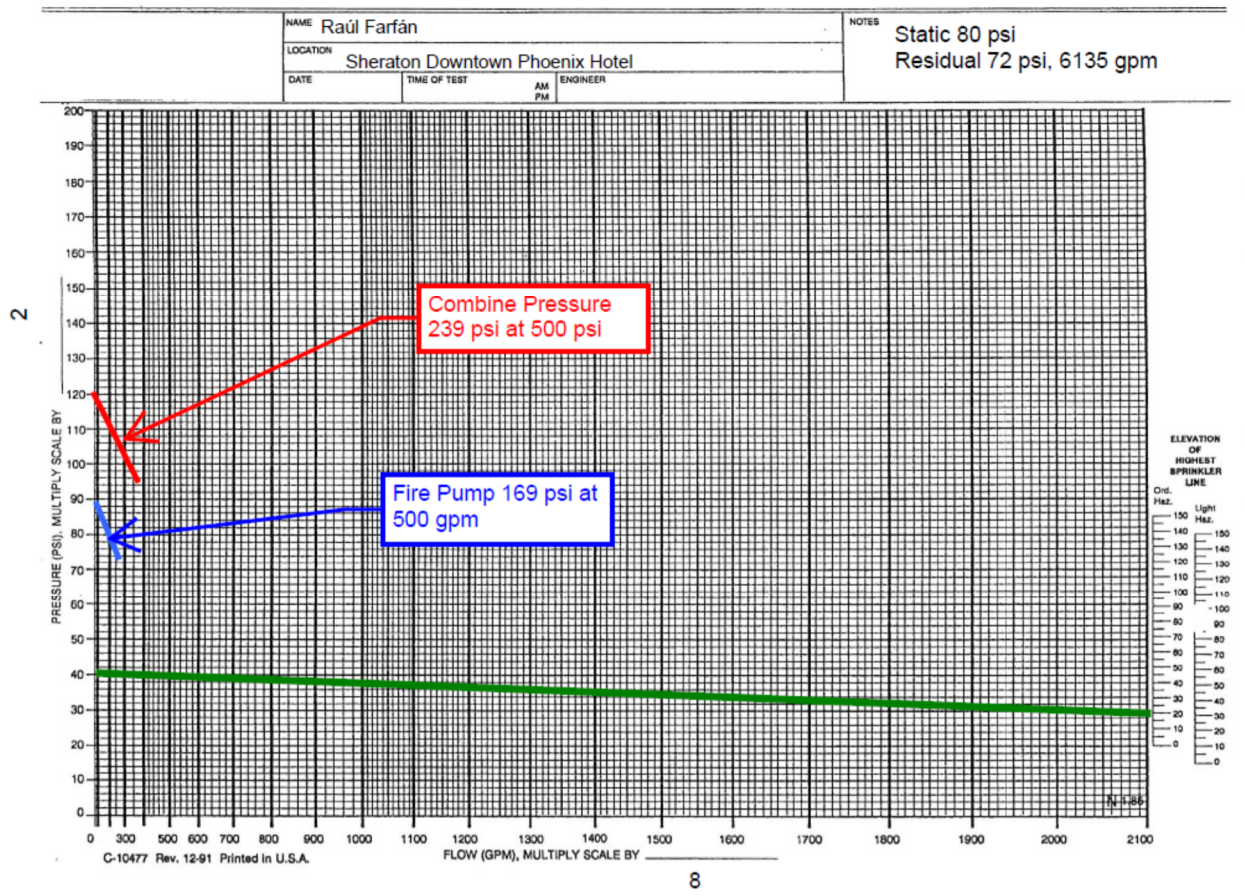


Figure 24: Hydraulic Graph

ANSUL Restaurant Fire Suppression Systems

On level one (1) there is a kitchen in the restaurant that has an ANSUL Restaurant Fire Suppression System. The system is installed per NFPA 96, Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations, and NFPA 17A, Standard for Wet Chemical Extinguishing Systems. ANSUL has a third party listing from Underwriters Laboratory, Inc. as a pre-engineered system. The listing approval is under the UL 300 standard, which test for fires in deep fat fryers, ranges, griddles, char-broilers, woks, up-right broilers, filters, plenums chambers, hoods, and ducts after pre-loading the appliances with a prescribed amount of grease.

The kitchen fire system is an automatic fire suppression system with manual pull station to meet the NFPA 96 standard. Upon activation the fuel and electrical power for the kitchen will be shut off per the NFPA standard, this is done by ANSUL by providing a relay switch that has gone through the UL testing. ANSUL states that electrical connection must be done by a qualified electrician to verify it has been installed properly. As well as the kitchen electrical switch ANSUL also provides and electrical switch that will connect directly to the main fire alarm panel.

The device is called the ANSUL AUTOMAN and allows the system to comply with the NFPA 96 standard. This connection much like the kitchen electrical shut off will have to be done by a qualified electrician.

Further details on the appropriate installation methods and nozzle locations can be found in the ANSUL manual.

Fire Suppression Summary

The Sheraton Hotel has the appropriate suppression systems installed per the IBC 903, NFPA 13, and 14 standards. The hotel has three types of hazards; light, ordinary I, and ordinary II, which are distributed along the floor levels. There is a special hazard suppression system installed in the restaurant's kitchen. ANSUL restaurant fire suppression system is a UL listed product that meets the requirements of IBC 904.11. The next section of the report will elaborate on the maintenance requirements of the fire suppression systems.

Maintenance of Fire Suppression Systems

General Maintenance

The general responsibility of fire suppression system maintenance falls under the property owner or a determined designated representative per section 4.1.1 of NFPA 25. The building shall be ensuring that the minimum temperature of the building is 40°F (4.4°C) since the sprinklered system is a water based system. Since the building is in Arizona there is no tendency of the ambient temperature falling below 40°F (4.4°C) for a prolonged period of time. The property owner or designated representative shall provide ready accessibility to components of water based fire protection systems that required testing. Notification of the system shutdown shall be given to the appropriate AHJ. If any correction and repairs are found to be needed then the property owner or representative shall fix the item or contract qualified representative to correct the item.

If any obstructions, new uses of rooms, or modifications done from original design it must be reviewed by the AHJ and redesigned in order to be under the regulation and standards.

Sprinkler System Maintenance

The following sprinkler system inspection, testing, and maintenance schedule can be found in Table 5.1.1.2 of the NFPA 25.

Sprinklers will have to be inspected at floor level. No sign of leakage shall be free of corrosion, foreign materials, paint, physical damage, and the sprinkler shall be maintained in the correct orientation. If any damage or issues have been found in the sprinklers it shall be replaced.

Sprinkler pipes shall be inspected annually from the floor level. Pipes and fitting installed in concealed spaces are not required to be inspected.

Gauges shall be inspected monthly to ensure they are in good condition and that the normal water supply is being maintained.

Water flow alarms shall be inspected quarterly.

Sprinklers shall be replaced every 50 years or have a representative sample shall be tested. Afterwards ever test sample shall be done every ten years. Sprinklers manufactured before 1920 shall be replaced. Gauges shall be replaced every 5 years or if the accuracy falls below 3 percent.

No antifreeze solution is used in the Sheraton Hotel and thus not need to be subject to its maintenances.

Standpipe and Hose Systems

Table 6.1.1.2 of the NFPA 25 states the frequencies of standpipe and hose system inspection, testing, and maintenance that must be met.

Fire Pump Maintenance

Table 8.1.1.2 from the NFPA 25 shows the frequency of the maintenance schedule

Annual flow testing shall be done using the hose stream. The testing shall be done under minimum, rated, and peak flows of the fire pump by controlling the quantity of water discharged through approved test devices. Other maintenances shall be done according to the manufacturer's discretion.

ANSUL Restaurant Fire Suppression System Maintenance

Maintenance on the ANSUL systems must be conducted by an ANSUL certified technician.

The manufacturer requires the system to be maintenance semi-annually for a maximum of a 12 year. Within those 12 years there are additional test that must be done for example, hydrostatic testing on the cylinders. This section will summarize the maintenance requirements.

The semi-annual maintenance requires the technician to conduct the following tasks:

1) Deactivate the expellant cartridge and check for pressure and gasket of the expellant cartridge.
2) Disconnect expellant gas distribution hose and check for any obstructions or damage.
3) Disconnect distribution piping unions at each tank adaptor and remove agent storage tanks.
4) Remove tank adaptors and verify correct amount of agent in the tank.
5) Examine the threads of adaptor and fittings and return the system back into the original location.
6) Check nozzles, verify blow caps are installed, spring clips rotate correctly, and that the nozzles are free of grease.
7) Check manual pull station.
8) Remove and clean the fusible links and the detector lines and manual pull station equipment.
9) Re-activate the system.

For the 12 years maintenance there are additional steps in additional to the semi-annual inspections. The following are the additional steps that need to be done:

1) Hydrostatic test of expellant hose.
2) Hydrostatic test of expellant cartridge.
3) Regulator must be flow tested
4) Re-fill the agent storage tank with new ANSULEX agent

Maintenance of Fire Suppression Equipment Summary

As previously mentioned, the maintenance for this equipment is the responsibility of the building owner. Owner must follow NFPA 25 standard and the manufactures maintenance guides of equipment. It is recommended that the owner set up a contract, if owner has not done so already, for the maintenance of the fire suppression equipment in order to have an assurance that the equipment will work properly in case of a fire.

Fire Detection, Alarm, Communication, and Smoke Control Systems

Fire Alarm Systems

Alarm and signaling drawings of the building is not available to review in this building. Basic information of the fire alarm systems were received by the AHJ in order to fill in the information provided.

The fire alarm control panel installed in the building is an Edwards Fire Panel. The fire panel is located in the fire commander room on the first floor. Since the Sheraton Hotel is a high rise building floors, power boosters have been installed at each floor level.

The type of initiating devices for the panels are water flow switches with a tamper proof switch, smoke detectors, and duct smoke detectors.

The water flow switch is located on the main riser at ground floor. Smoke detectors are located near elevator lobbies, near stairway doors, and rooms.

Location, Spacing and Placement of the Fire Detection Devices

Since no plans were received, in this report we will establish the guidelines on how locations of the fire detection devices are expected to be in place using NFPA 72 guidelines. Section 17.7 of the NFPA standard describes the prescriptive methods of how the detectors shall be located.

In this section fire detection devices will not include the sprinkler detector since these detectors were discussed in the previous section.

The maximum spacing of the detectors is to be 30 ft. per detector. Other locations where smoke detectors are specifically located are near the elevator lobby and by the stairwell doors. Duct smoke detectors are placed on the building's HVAC systems.

Fire Alarms System Types, requirements and location

Similar to the detection portion of this section there were no plans given to evaluate the current layout. This report will focus on where the alarms need to be located per the NFPA 72 handbook. Speaker/strobe alarms are to be located in the common places, speakers were place in hotel rooms, and strobe lights are placed in the ADA rooms.

Locations of the alarms are not currently known. However for the sake of the report we will review the requirements per the NFPA 72 handbook.

Per NFPA 72 standard Section 18.4.8.1 all audible wall mounted devices shall have their tops above the finished floor at heights of not less than 90 in. and below the finished ceiling at a distance of not less than 6 in unless it's an audible/visible device, it's an integral part of the smoke detector, or if mounting height other than the prescriptive requirements meet the appropriate sound pressure requirement for appropriate application. Requirements for audible alarms must be 15 dBA louder than the service area of the room per NFPA 72 Section 18.4.3.1. Table A.18.4.3 gives examples of service areas and their typical decibel ratings.

TABLE A.18.4.3 *Average Ambient Sound Level According to Location*

Location	*Average Ambient Sound Level (dBA)*
Business occupancies	55
Educational occupancies	45
Industrial occupancies	80
Institutional occupancies	50
Mercantile occupancies	40
Mechanical rooms	85
Piers and water-surrounded structures	40
Places of assembly	55
Residential occupancies	35
Storage occupancies	30
Thoroughfares, high-density urban	70
Thoroughfares, medium-density urban	55
Thoroughfares, rural and suburban	40
Tower occupancies	35
Underground structures and windowless buildings	40
Vehicles and vessels	50

Figure 25: NFPA 72 table A18.4.3 reference

The location of the audible device rating is only good for the first 10 lateral feet. To estimate the audible levels after the 10 ft. one can use the 6dBA rule of thumb. Figure 26 below shows an example of how the audible levels drop after the 10 ft.

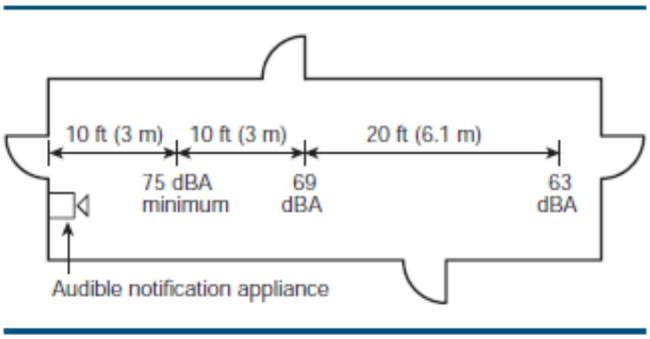
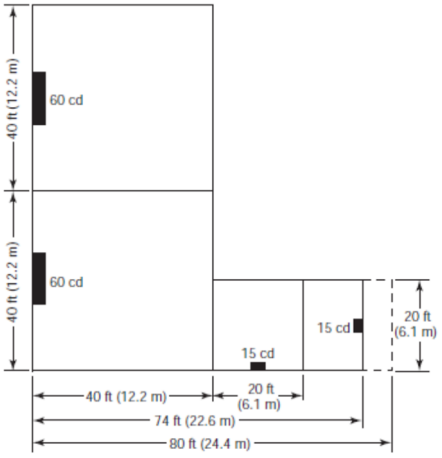


Figure 26: NFPA 72 Exhibit 18.11 reference

For visible strobe, the mounting height shall be from 80 to 96 inches. Any proposed locations that are above or below that height has to be followed with appropriate testing / evidence that it can meet correct illumination for that application per NFPA 72 section 18.5. Spacing of a strobe can is approximate a 40 ft^2 per a 60 cd strobe. Figure 27 below is the variation of the strobe limits.



Note: Broken lines represent imaginary walls.

FIGURE A.18.5.5.4(b) *Spacing of Wall-Mounted Visible Appliances in Rooms.*

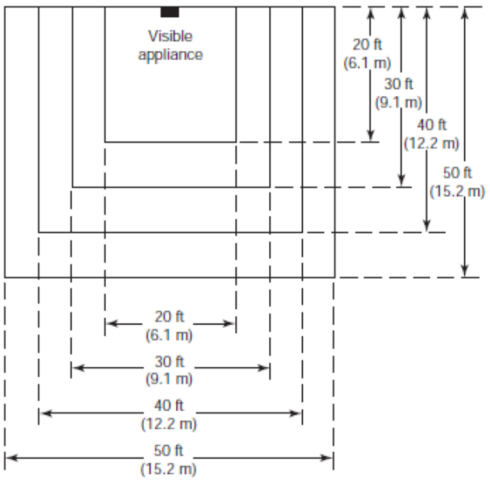


FIGURE 18.5.5.4.1 *Room Spacing for Wall-Mounted Visible Appliances.*

Figure 27: NFPA 72 – Figure 18.5.5.4.1 reference - Spacing of wall-mounted visible appliances

Various locations and limits of these appliances depend on the material used in the building and if there is any additional furniture placed throughout the buildings floor plan.

Mass Notification System

The AHJ stated that there is no mass notification device installed in the Sheraton Downtown Phoenix Hotel. Upon review mass notification systems is not required by the IBC code in this building.

Power Requirements for the Fire Alarm and Communication Systems

All the power supplies used for the alarm equipment shall be in conformity with the requirements of NFPA 70, National Electrical Code per Section of 10.6.2 of the NFPA 72. Each power supply shall have the adequate capacity for the application. The power supply shall also have an Uninterruptible Power Supply (UPS). The UPS will have to be configured to NFPA 111, standard on Stored Electrical Energy Emergency and Standby Power Systems, for a Type O, Class 24 Level 1 system. Any failure of the UPS systems shall trigger a trouble signal per Section 10.6.4.3 of NFPA 72 and this trouble signal shall meet the requirements in Section 10.15 of the same NFPA 72 standard.

The primary power supply shall meet the requirement of Section 10.6.5 of NFPA 72. The location of the branch circuit disconnecting means shall be permanently identified as to its purposes per Section 10.6.5.2 of NFPA 72. The branch circuit shall also have a mechanical protection and a circuit breaker lock per Section 10.6.5.3-4 of the NFPA 72 standard.

The secondary power supply shall be able to operate within 10 seconds from whenever the primary power supplies fails. The secondary power supply shall only provide the minimum voltage required for proper operations according to Section 10.6.6.1 of NFPA 72. This secondary power supply shall be able to provide a minimum of 24 hours or power and at the

end of the 24 hours be able to sound an alarm for 5 minutes per Section 10.6.7.2.1 in NFPA 72 or unless the requirement below is acceptable or required by following the bullets below.

- Battery calculation shall include a 20 percent safety margin to the calculated amp-hour rating
- Secondary power shall work for 24 hours idle time then 15 minutes of alarm time.
- Supervising station shall be capable of supplying power to the operations for 24 hours

The second power supply shall consist of one of the following, storage battery or an automatic-starting, engine-driven generator. If there is a generator used then the generator does not have to be a dedicated to the fire alarm systems according to Section 10.6.7.3.1

Storage batteries shall be marked with the month and year of manufacture, per section 10.6.10.1 of NFPA 72. Batteries shall be located so that the equipment so that the equipment shall not get affected by battery gases ad shall conform to requirements of NFPA 70, per Section 10.6.10.2 of NFPA 72. Below are standard picture of typical batteries.

Recharging of the batteries must be done within 48 hours after the batteries have been discharged. Protection for the batteries and the overcurrent issues must be looked at and have the risk of unwanted event reduced.

If batteries are not used as a secondary power supply an engine-driven generators for secondary power must be installed per NFPA 70 national electrical code, article 700.

For this project, no alarm signaling devices drawings were able to be shared to finish the evaluation of the Sheraton Hotel. Given the conversation with the AHJ, there is a 24 hour battery source provided to the alarm signaling devices as a secondary power source.

Commissioning and Inspection, Testing and Maintenance of Alarm Systems

Before testing the AHJ and the system contractor are required to ensure that all documentation of the system installation has been completed.

Requirement under Chapter 14 of the NFPA 72 standard requires the system to be inspected tested in a particular manner under the chapter. The owner or the representative of the building is responsible for the execution of the program. If there are any modifications of the systems, the modification and proposed test plan must be submitted to the AHJ prior to actualizing the change.

Visual inspection of the equipment shall follow Table 14.3.1 in Section 14.3 in the NFPA 72. All the equipment is to be inspected annually except for some items that will have to be inspected semiannually and weekly. The semiannual items are the trouble signals in the control equipment, in-building fire emergency voice, some types of batteries, remote annunciators, transient suppressors, and initiating devices. Weekly inspections are for fuse, interfaced equipment, lamps and LEDs, and power supply.

Testing of the devices is required per section 14.4 in NFPA 72 standard. Table 14.4.3.2 gives a rundown of all the testing required for the equipment and at what frequencies. Most of all the equipment has an annual test schedule. The equipment's that need semiannual testing are the battery charging equipment, public emergency alarms, and master box.

Per section 14.6.2 in NFPA 72 maintenance, inspection, and testing records shall be kept until the next test and then after a minimum on 1 more year.

Smoke Control Systems

According to the AHJ the hotel has a smoke control system that pressurizes the stairwells. The amount of information given was that the smoke control system complies with the prescriptive design that the smoke control system meets is per the IBC Section 909 and that the activation of the system is through a water flow test and smoke detection near the stairwells.

The minimum pressure differences that across the smoke barrier and the stairwell is 0.1-inch water and maximum pressure is 0.35 inch water per Section 909.20.5. The maximum building pressure is required not to be greater than the maximum allowed force to open exit doors.

There are no exhaust systems installed therefore sections in Section 909 that discusses exhaust components will be omitted.

According to Section 909.10.2 ducts shall withstand probable temperatures that they may be exposed. Determination of the temperature can be found in Section 909.10.1 equation 9-3 of the IBC. Ducts construction must also comply with the International Mechanical Code and leak tested at 1.5 times the maximum design pressure.

Inlet and outlet equipment is required to be located in a location where there is no additional occupant involvement and out of additional fire hazards. The inlet portion shall be located to minimize the probability of introduction additional smoke to the building and the exhaust shall be located to minimize the introduction of smoke to the building. This is stated in Section 909.10.3

Automatic dampers shall be listed by a recognized third part approval agency per IBC 909.10.4. Fans, if they are a belt driven fan, shall have 1.5 times the number of belts require for the belt duty but no less than two belts. The fans shall be selected to operate well at normal and elevated ambient temperatures per IBC Section 909.10.5

Dual power sources shall be required for the smoke control system. One of the power sources shall be from the normal operating electrical power source and the other by an approved stand by source per Section 909.11 of the IBC.

Detection and the control systems are tied together. The smoke detectors pressurize the stairwells according to section 909.12.2.1 and the water flow signal call under the automatic control per Section 909.12.3.

Control Diagrams and identification markings are located in the Fire Command Center of the building per Section 909.14 through 909.16.

System must go through an acceptance test per IBC Section 909.19.

Maintenance for the Smoke Control System

According to IBC Section 909.19 after complying with system acceptance test if must have a maintenance program according to IFC 909.20.

The maintenance program is to be established by the manufacturer requirements and IFC section 909.20.1 through 909.20.5.

The routine maintenance and operational test shall be initiated immediately after the smoke control has passed the initial test. A written schedule for maintenance shall be written and established.

A written record shall be maintained on the premises. Date of maintenance, identification or servicing personal, and notification of any unsatisfactory condition with corrective action taken shall be noted as well as any replace components.

Testing of smoke control systems includes the following equipment:

- Initiating devices
- Fans
- Dampers
- Controls
- Doors
- Windows

Dedicated smoke control system shall be operated for each control sequence semi-annually and tested with standby power as well.

Non-dedicated smoke control system shall be operated for each control sequence annually with standard power and standby power.

Fire Alarm, Detection, Communication, and Smoke Control System Summary

The Sheraton Hotel has audible and visual alarms to alert its occupants throughout the building and compliance with the NFPA 72 standard. The detection devices used in the hotel are smoke detectors, duct smoke detectors, and flow switches. The smoke detectors will be installed along the elevator lobbies, stairwells, guest rooms, and ducts. The alarms and detection system have a UPS system of 48 backup power using batteries. The hotel does not have a mass notification system communication. A smoke control system is installed per IBC 909 and only activates automatically when the smoke detectors along the stairwells activate. The next section will discuss emergency planning and preparedness that is required for the staff.

Emergency Planning and Preparedness

Fire Safety and Evacuation Plans

Due to the fact that the hotel also serves as a group A/B//High rise building, a Fire safety evacuation plan is required per section 404 of the IFC.

Fire Safety Plans

Per IFC 404.3.2, Fire Safety plans shall contain the following:

1. The procedure for reporting a fire or other emergency
2. The life safety strategy and procedure for notifying relocating or evacuating occupants, including occupants who need assistance.
3. Site Plan indicating the following
    a. The occupancy assembly point
    b. The location of fire hydrants
    c. The normal routes of fire department vehicle access
4. Floor plans identifying the location of the following:
    a. Exits
    b. Primary evacuation routes
    c. Accessible egress routes
    d. Areas of refuge
    e. Exterior areas for assisted rescue
    f. Manual fire alarm boxes
    g. Portable fire extinguishers
    h. Occupant-use hose stations
    i. Fire alarm annunciators and controls
5. A list of major Fire hazards associated with the normal use and occupancy of the premises, including maintenance and housekeeping procedures
6. Identification and assignment of personnel responsible for maintenance of systems and equipment installed to prevent control fires
7. Identification and assignment of personnel responsible for maintenance, housekeeping and controlling fuel hazard sources

Fire Evacuation Plans

Per IFC 404.3.1, fire evacuation plans shall contain the following:

1. Emergency egress or escape routes and whether evacuation of the building is to be complete or, where approved, by selected floor or areas only
2. Procedures for employees who must remain to operate critical equipment before evacuating
3. Procedures for assisted rescue for persons unable to use general means of egress unassisted
4. Procedures for accounting for employees and occupants after evacuation has been completed

5. Identification and assignment of personnel responsible for rescue or emergency medical aid
6. The preferred and any alternative means of notifying occupants of a fire or emergency
7. The preferred and any alternative means of reporting fires and other emergencies to the fire department or designated emergency response organization
8. Identification and assignment of personnel who can be contacted for further information or explanation of duties under the plan
9. A description of the emergency voice/alarm communication system alert tone and preprogrammed voice message, where provided

Emergency Evacuation Drills

Emergency evacuation drills are required for this facility according to the IFC 405 code. Drills are required for the occupancies in the building at the intervals specified in the Table 24 below.

Table 24: Drill evacutation frequency for the building

Fire and Evacuation Drill Frequency and Participation		
Group or Occupancy	**Frequency**	**Participation**
Group A	Quarterly	Employees
Group B	Annually	Employees
High-Rise Building	Annually	Employees

Leadership, timing, procedure, and record keeping drills shall be in accordance with IFC section 405. Drills shall be designed in cooperation with the local authorities. Complete evacuation for the building of all persons required to participate is required. It is against the law to refuse to participate or interfere with fire department conducting emergency drill.

Hazard Communication

Hazardous material may be present on the site. An example of such material would be cleaning chemicals in storages and closet. Such material must be properly identified.

Material Safety Data Sheets (MSDS) for all hazardous material shall be either readily available on the premises as a paper copy, or where approved, shall be permitted to be readily retrievable by electronic access. Individual containers of hazardous material, cartons or packages shall be marked or labeled in accordance with applicable federal regulations. Building, rooms, and spaces containing hazardous materials shall be identified by hazard warning signs in accordance with the IFC Section 5000.

Fire Safety during Construction

The IFC Chapter 33 contains requirement for fire safety during construction. The following requirements will apply to this Sheraton Hotel building during remodeling construction.

Access for Fire Fighting

Approved vehicle access for firefighting shall be provided to all construction of demolition sites per Section 3310 of the IFC. Vehicle access shall be provided within 100 feet of temporary or permanent fire department connections. Vehicle access shall be provided by either temporary or permanent roads, capable of supporting vehicle loading under all weather conditions. Vehicle access shall be maintained until permanent fire apparatus access roads are available.

Means of Egress

Per Section 3312 an approved water supply for fire protection, either temporary or permanent, shall be made available as soon as combustible material arrives on the site.

Water Supply for Fire Fighting

An automatic sprinkler system is provided in accordance to Section 1103.5.1 which states that sprinkler shall be installed throughout existing buildings where cellulose nitrate film or pyroxylin plastics are manufactured, stored, or handled in quantities exceeding of 100 lbs. The sprinkler shall be capable of discharging 1.66 gallons per minute per square foot over the area of vault.

Standpipes

Existing structure shall be equipped with standpipes installed in accordance with Section 905. The fire code official is authorized to approve the installation of manual standpipes systems to achieve compliance with Section 1103.6.1 which states that existing multiple-story buildings located more than 50 feet above or below the level of fire department access shall have standpipes.

For building being demolished and a standpipe is existing within such a building, such standpipe shall be maintained in an operable condition so as to be available for use by the fire department. Such standpipe shall be demolished with the building but shall not be demolished more than one floor below the floor being demolished.

Portable Fire Extinguishers

Per Section 3315, structures under construction, alteration, or demolition shall be provided with not less than one approved portable fire extinguisher in accordance with Section 906 and sized for not less than ordinary hazard as follows:

- At each stairway on all floor levels where combustible materials have accumulated
- In every storage and construction shed.
- Additional portable fire extinguishers shall be provided where special hazards exists including, but not limited to, the storage and use of flammable and combustible liquids.

Emergency Planning and Preparedness Summary

The owner of the building and its management staff are responsible in conducting and recording the training of its staff. It is assumed that the training of the staff and its documentation upkeep is up to date. If the guidelines of the evacuation drills and upkeep of the MSDS paperwork is burdensome it is highly recommended to hire contractor to follow through with an emergency preparedness drills and plans.

Conclusion

This report reviewed compliance of prescriptive codes for levels one (1) through four (4) of the Sheraton Hotel. The hotel is evaluated under the 2012 IBC, IFC, and applicable NFPA standards. Under this code the site plans/fire service features, building fire protection and life safety features, building heights, areas, and construction type, fire restrictive construction, fire restrictive components, opening and penetrations, interior finishes, fire protection systems, smoke control systems, and detection/alarm/communication systems are compliant with the prescriptive methods mentioned in the codes and standards. The main egress requirements are met but there were two service areas that deviated from the code.

The first area that has an egress concerns is the terrace service area on level two (2). The egress doors do not meet the door separation width per Section 1008.1.2. It is recommended that the door separation be lengthened in order for the terrace to comply with the code. The next egress concern is the north doors in the main ballroom in level three (3). There is an encroachment issues on four double doors that have vestibules. The doors in these vestibules restrict the flow of egress. The swing of the door obstructs 55% of the vestibule width where the occupant will be exiting and goes against the IBC Section 1005.7.1. The section states that the door at full swing cannot reduce the required width by 7 inches and anytime during the swing by more than 50%. It is recommended that the vestibule width increases to meet the encroachment requirements. The other option is to not use these doors as a means to egress but when the main ballroom is used with its partition walls, section B, E, and C of the main ballroom will have to be limited to 49 occupants or less. Once these concerns are addressed the mean egress requirements for the hotel will be met.

This report showed the results of two performance base analyses. The first one is a lobby couch fire on level one (1) and the second one is a kiosk fire in the main ballroom on level three (3). The objective of the first scenario was to verify that the atrium in the main lobby area will not affect the egress of the occupants in the pre function on level two (2). A tenability criteria and egress time was established to evaluate the results. The first scenario did not pass as visual and toxicity tenability failed. This atrium does not have a smoke control system because of exceptions in the IBC. However, because there are a heavy fuel loads on level one (1), it is recommended that a glass wall be installed to prohibit the smoke to inhibit the egress capability of the occupants in the pre-function area. The second performance based analysis objective is to verify that occupants can egress from a tradeshow kiosk fire in the main ballroom on level three (3) as well as to verify if flame spread is a concern in such event. This analysis showed that occupants are able to exit before tenability criteria failed and the model in the performance based design showed sprinkler activation prior to the fire spread. No additional recommendation is needed for this performance based analysis.

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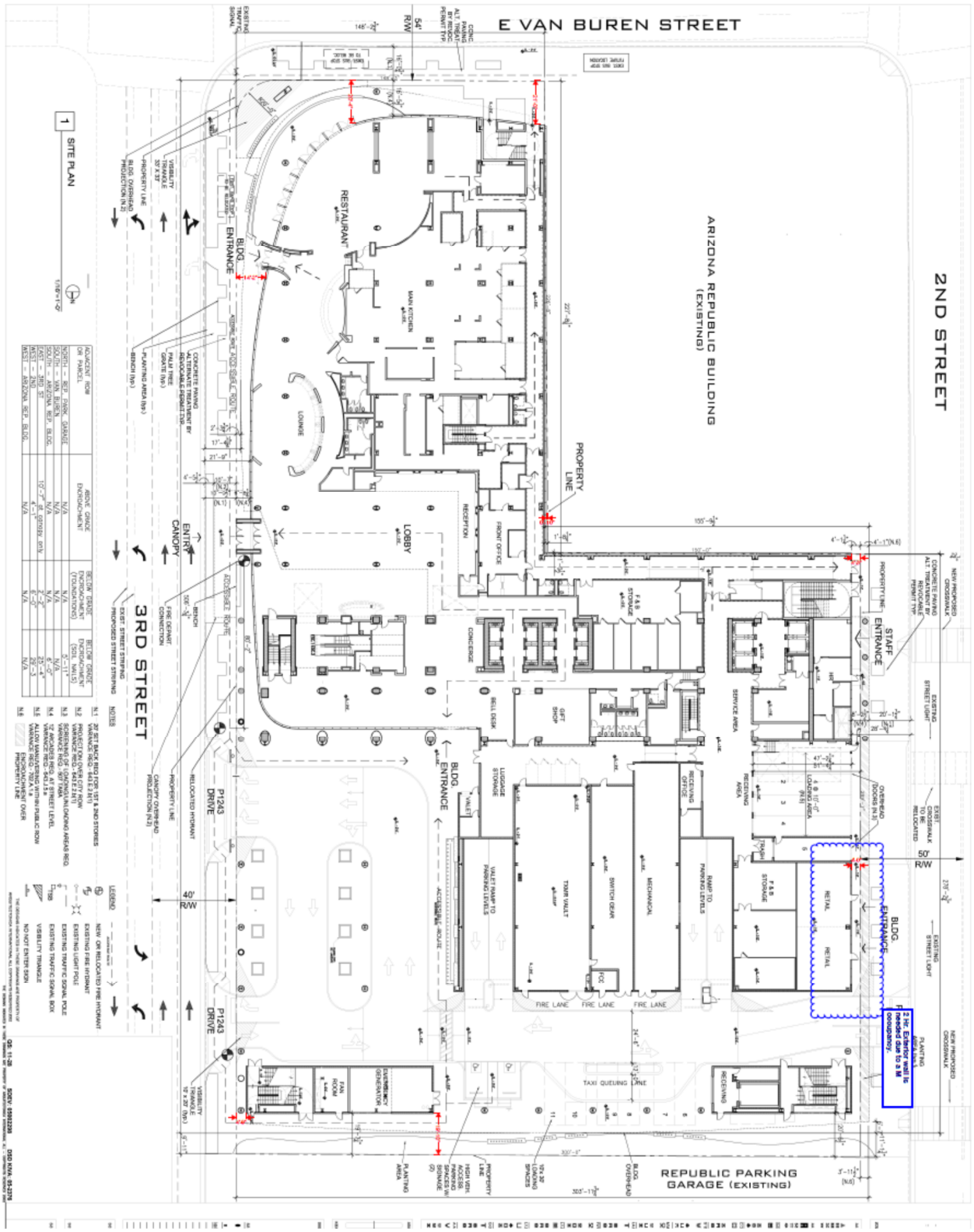
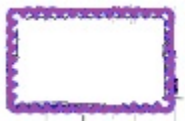
Appendix A: Property Line Distance


E VAN BUREN STREET
ARIZONA REPUBLIC BUILDING (EXISTING)
2ND STREET
3RD STREET
RESTAURANT
LOBBY
RECEPTION
FRONT OFFICE
CONCIERGE
BELL DESK
GIFT SHOP
LOUNGE
MAIN KITCHEN
SERVICE AREA
RECEIVING AREA
RECEIVING OFFICE
LUGGAGE STORAGE
VALET
VALET RAMP TO PARKING LEVELS
TRANSFORMER VAULT
SWITCH GEAR
MECHANICAL
RAMP TO PARKING LEVELS
F & B STORAGE
RETAIL
RETAIL
STAFF ENTRANCE
BLDG. ENTRANCE
BLDG. ENTRANCE
BLDG. ENTRANCE
ENTRY CANOPY
PROPERTY LINE
P1243 DRIVE
P1243 DRIVE
40' R/W
50' R/W
54' R/W
FIRE LANE
FIRE LANE
FIRE LANE
TAXI QUEUING LANE
REPUBLIC PARKING GARAGE (EXISTING)
2 Hr. Exterior wall is required due to 3 M Occupancy
1 SITE PLAN

Appendix B: Exits and Interior Stairways

Exits Doors 

Exit Stairways 

Exit Corridors 

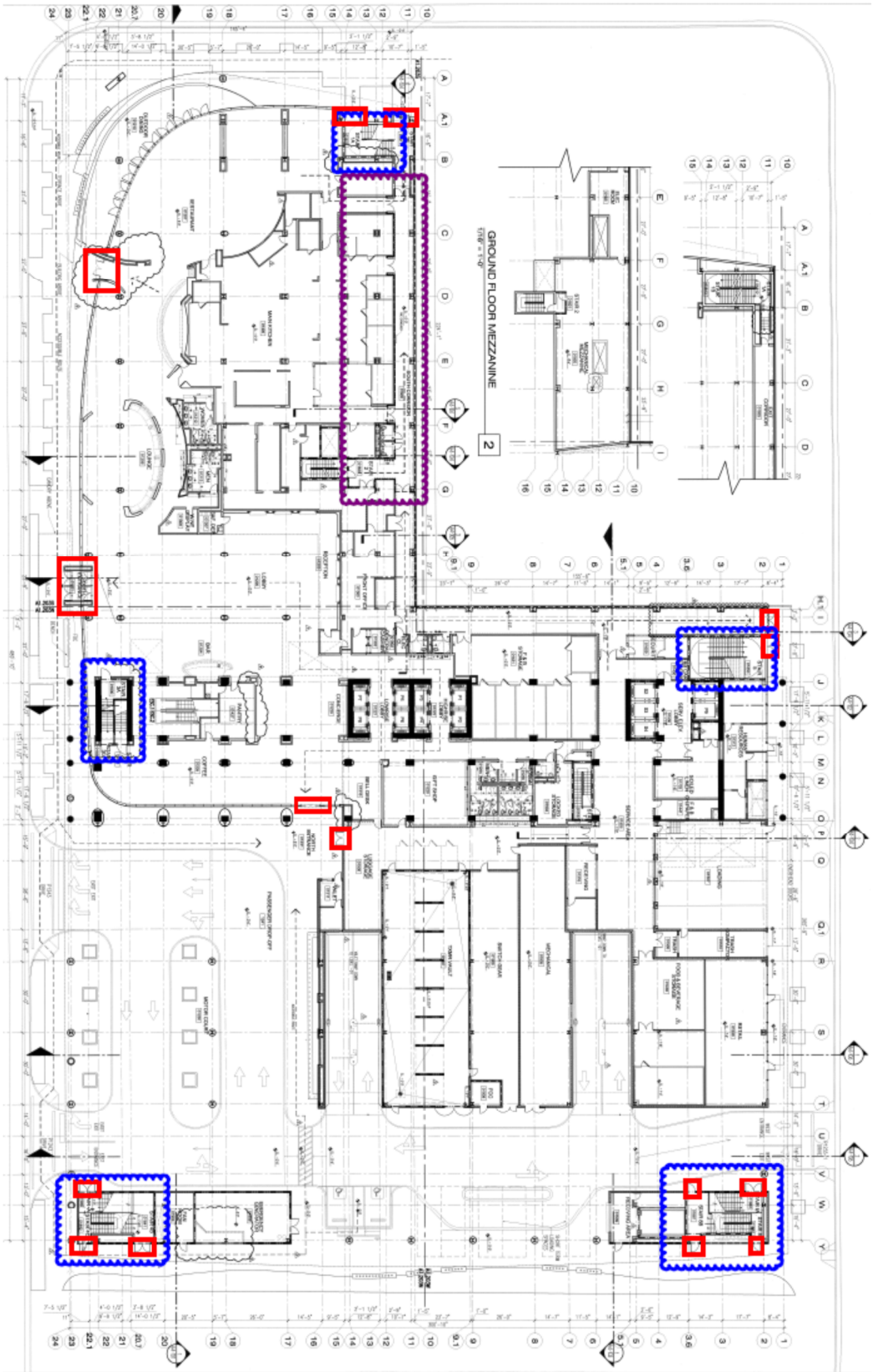


Figure 28: Ground Floor

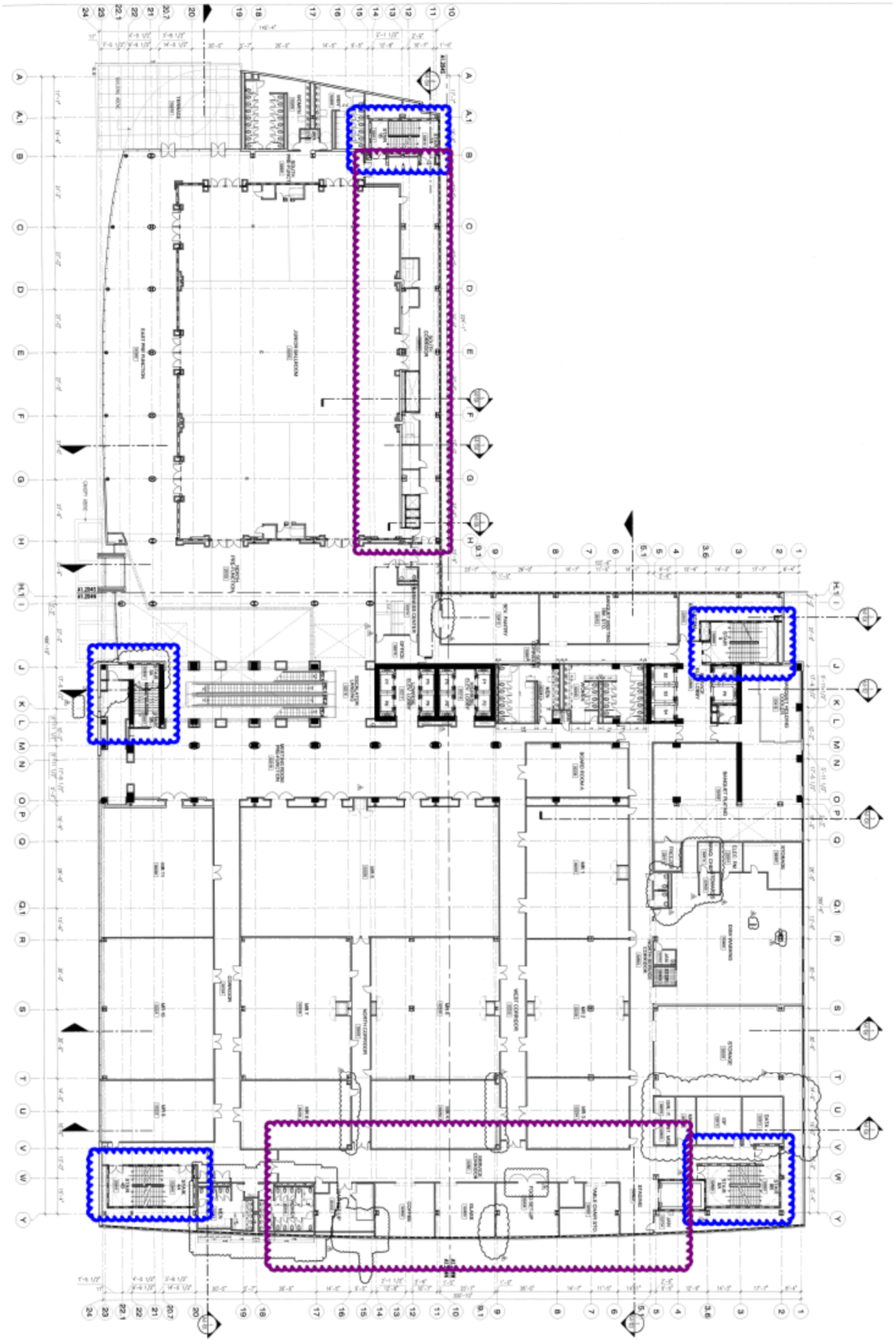


Figure 29: Level 2

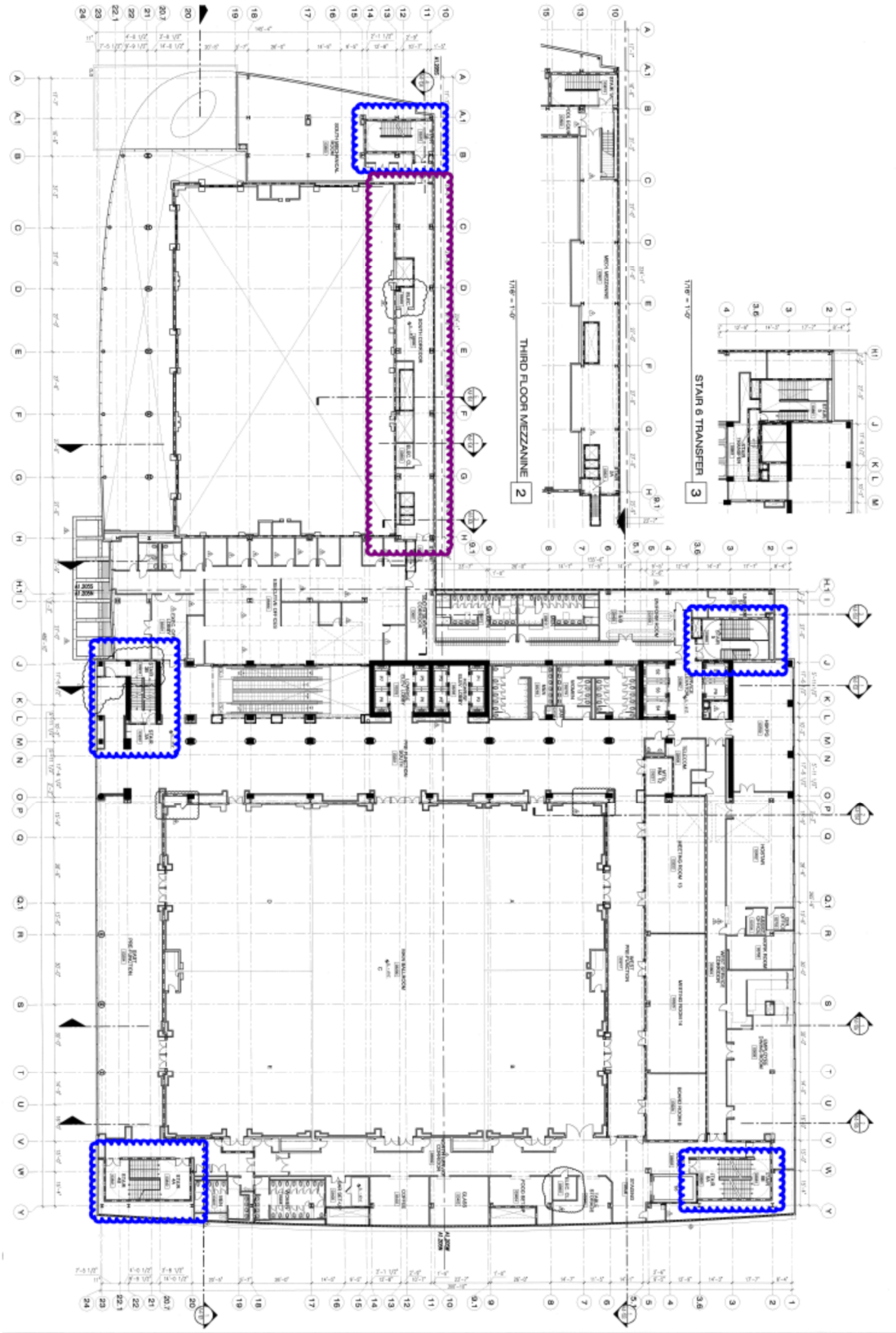


Figure 30: Level 3

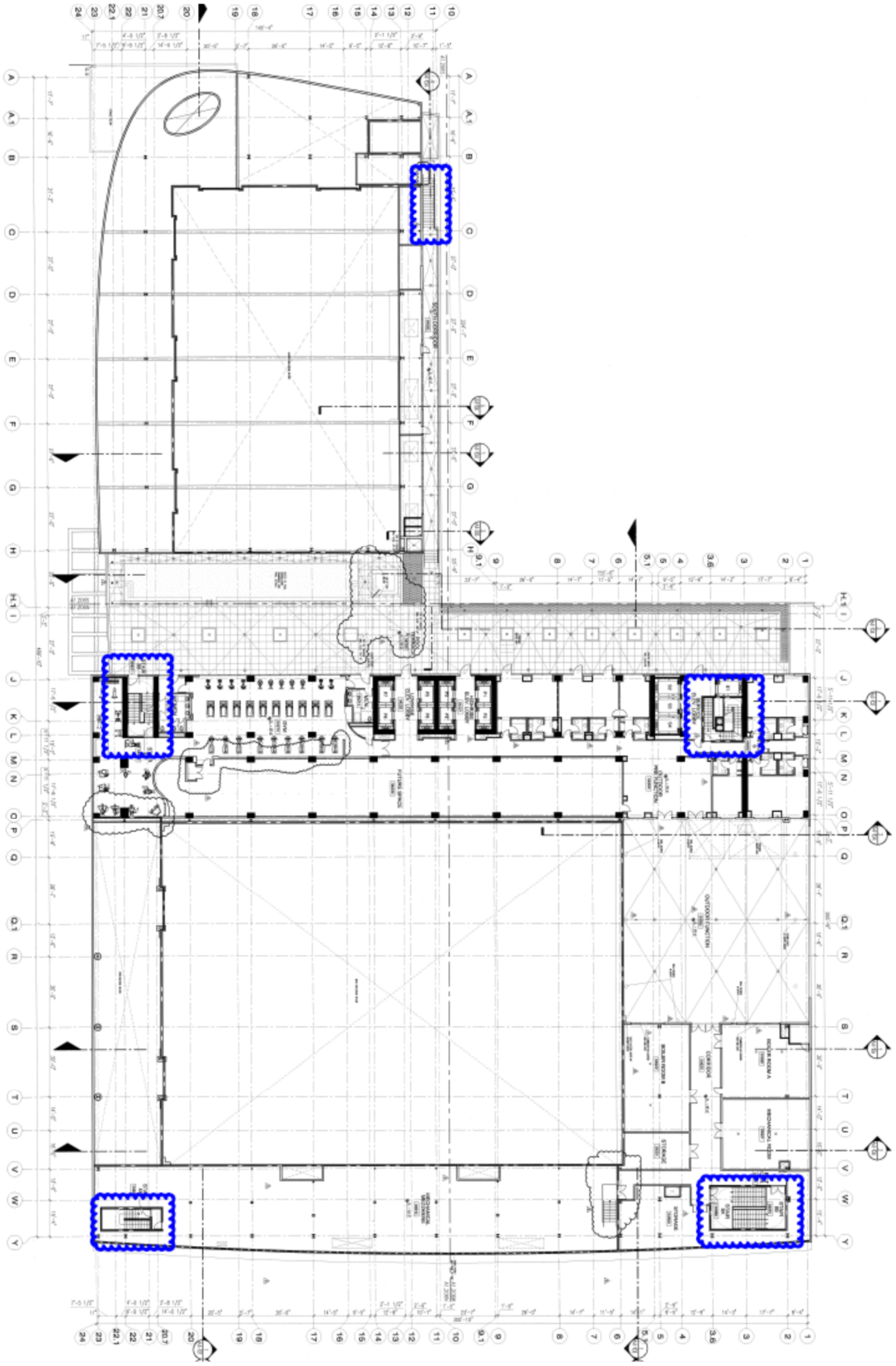


Figure 31: Level 4

Appendix C: Occupant load classification and its load

IBC 2012 Classification	
Space Designation	**Example Color Codes**
Assembly Group A-2	
Assembly Group A-3	
Business Group B	
Mercantile Group M	
Storage Group S-1	
Storage Group S-2	

Figure 32: Ground Floor

Figure 33: Level 2

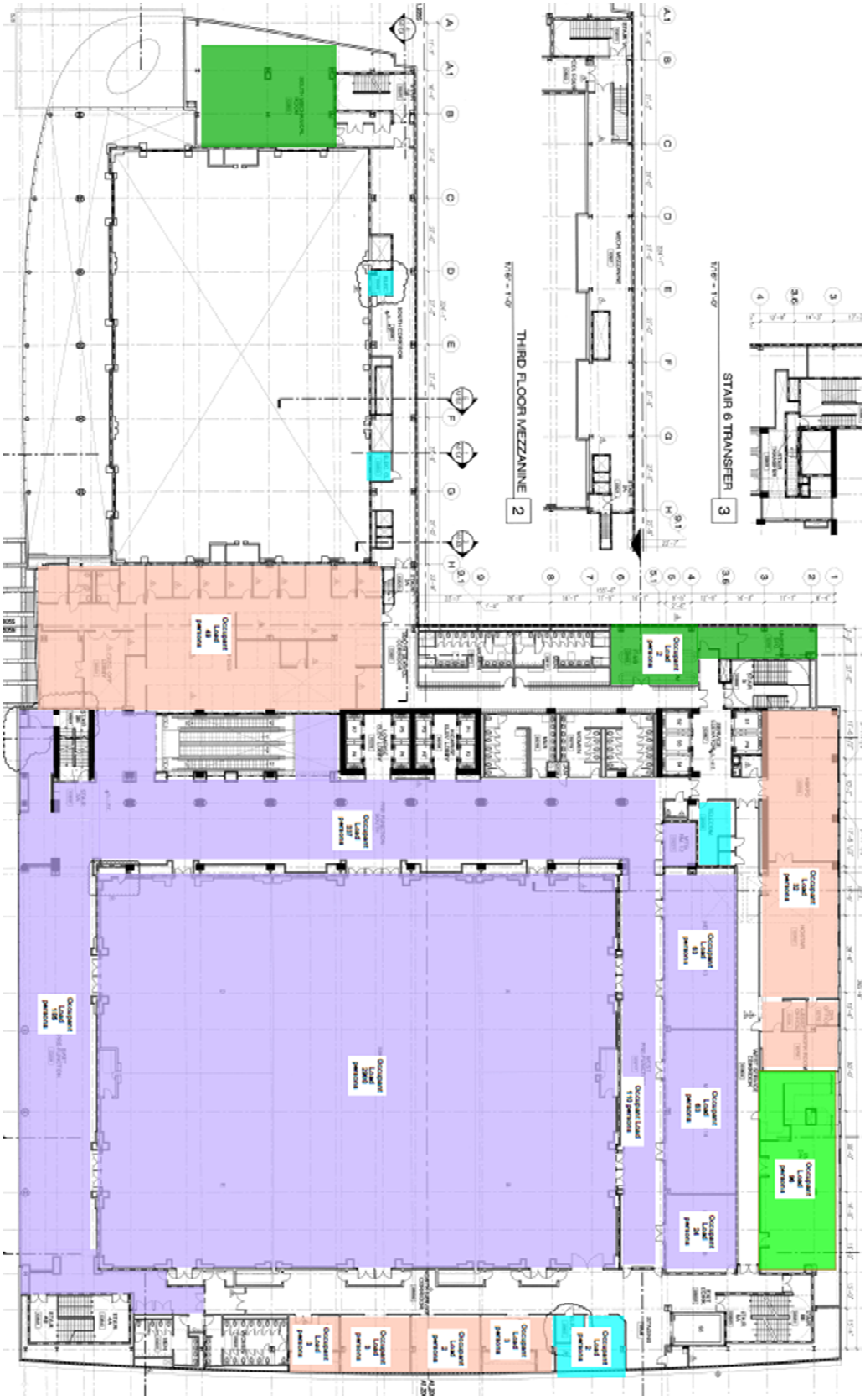


Figure 34: Level 3

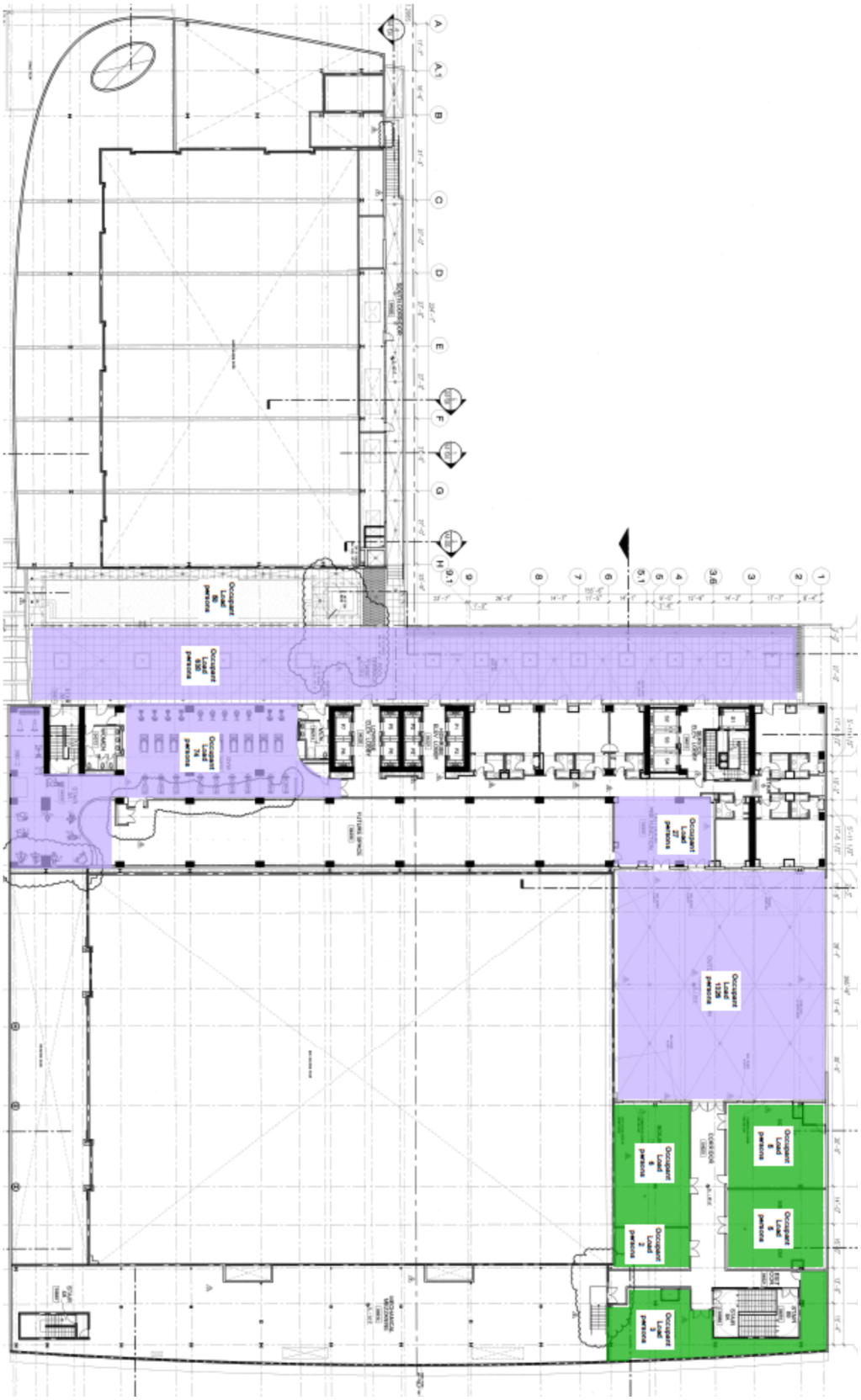


Figure 35: Level 4

Appendix D: Exit capacities

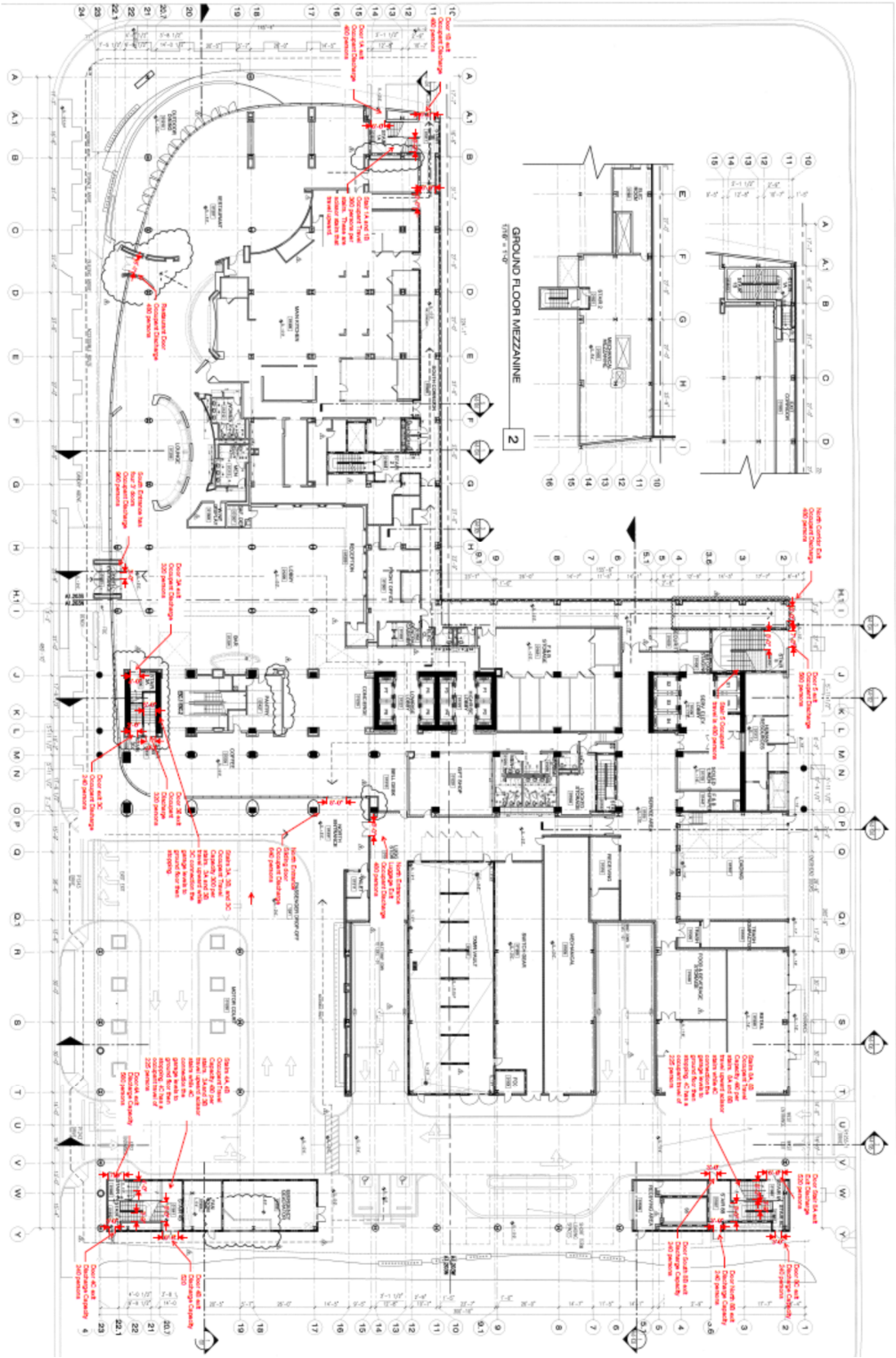


Figure 36: Ground floor

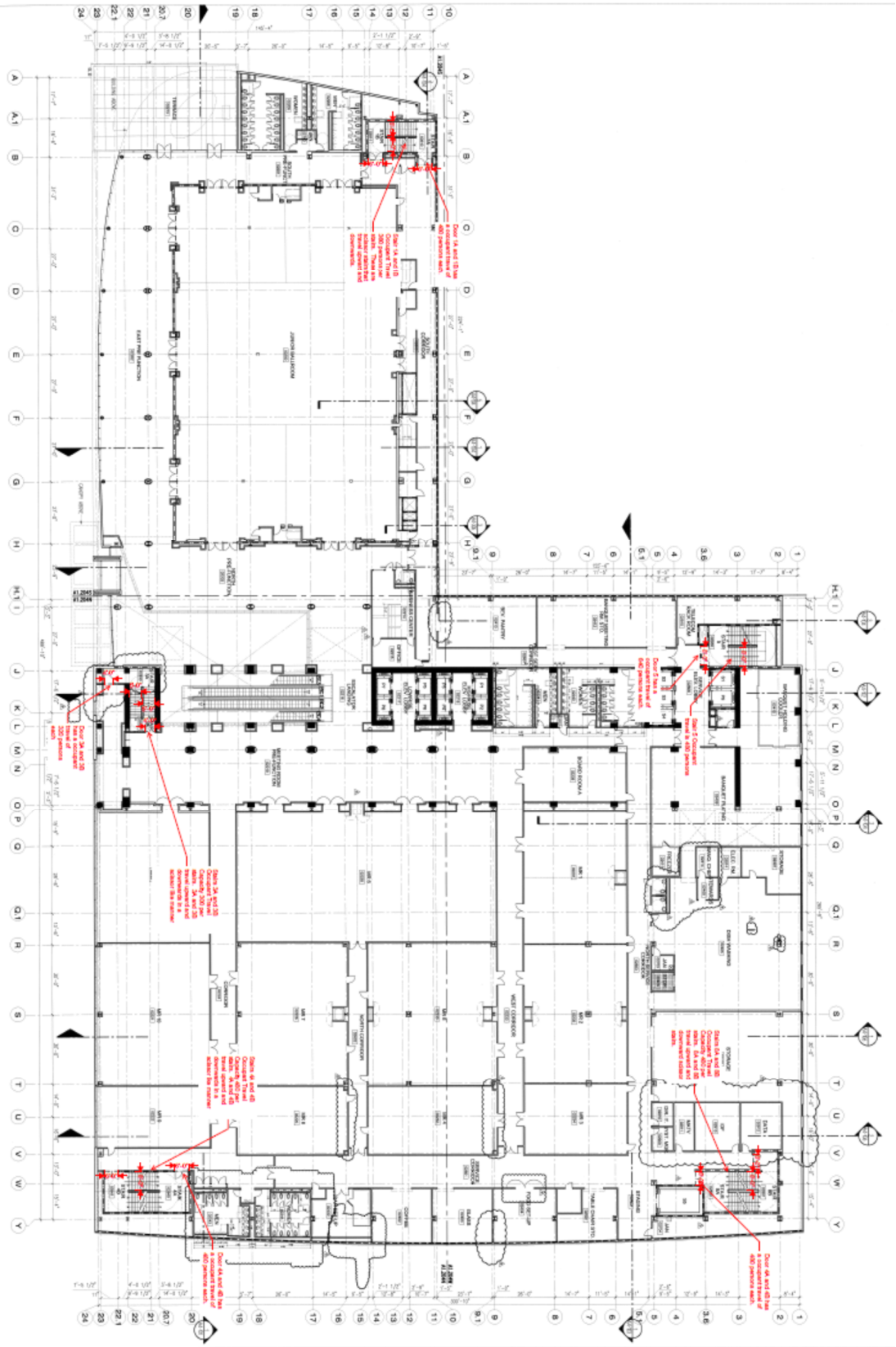


Figure 37: Level 2

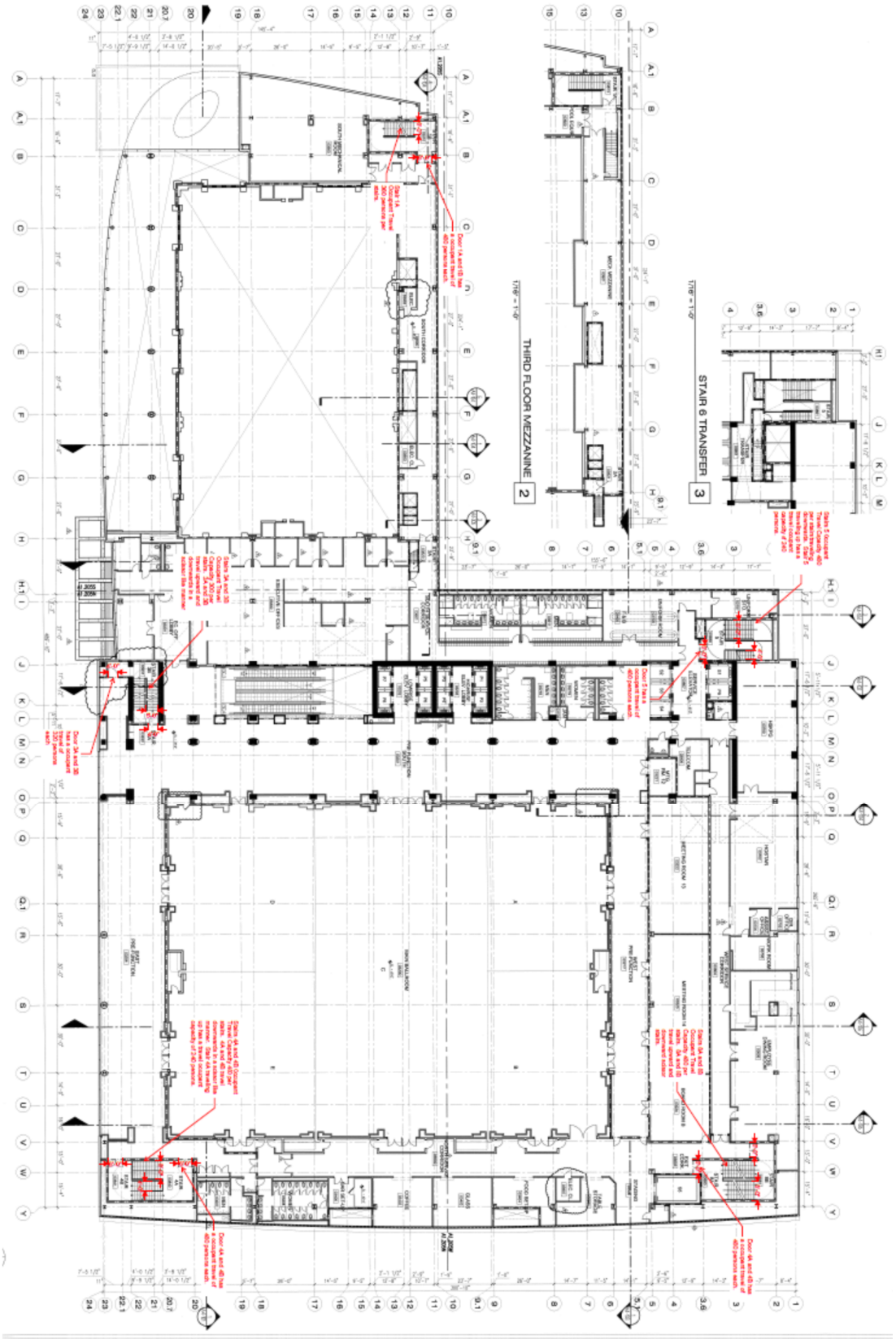


Figure 38: Level 3

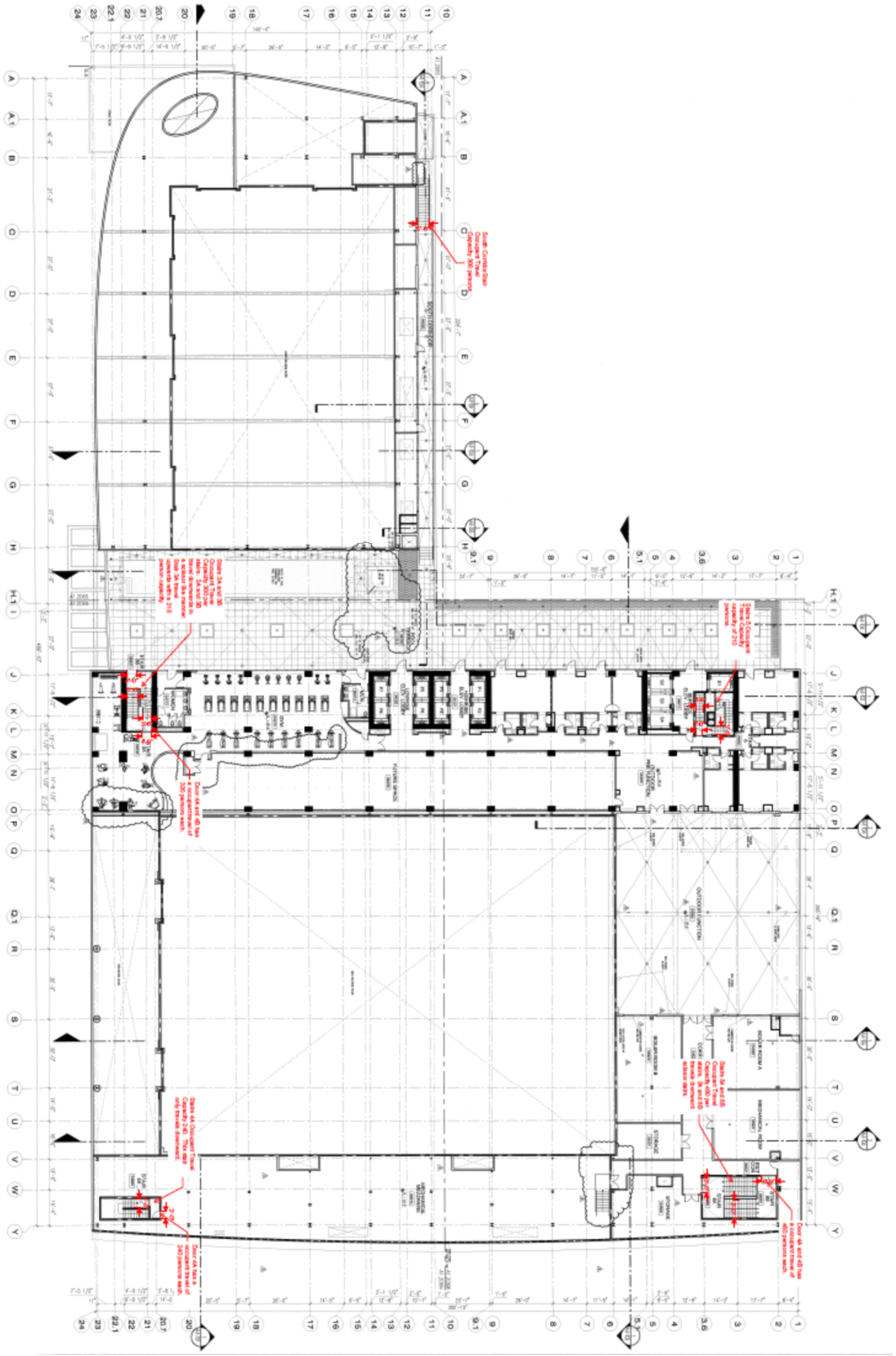


Figure 39: Level 4

Appendix E: Exit signs recommendation

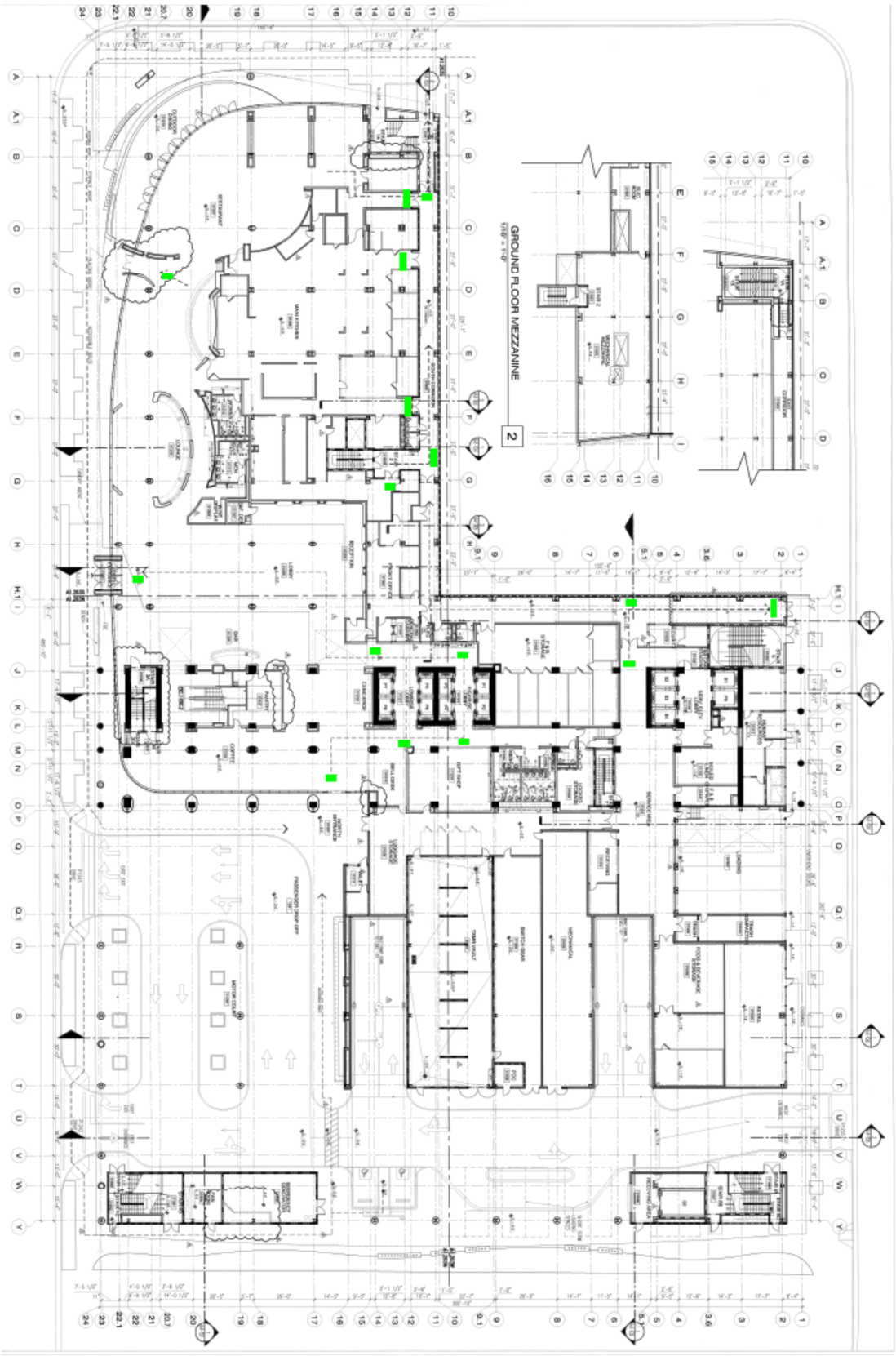


Figure 40: Ground floor

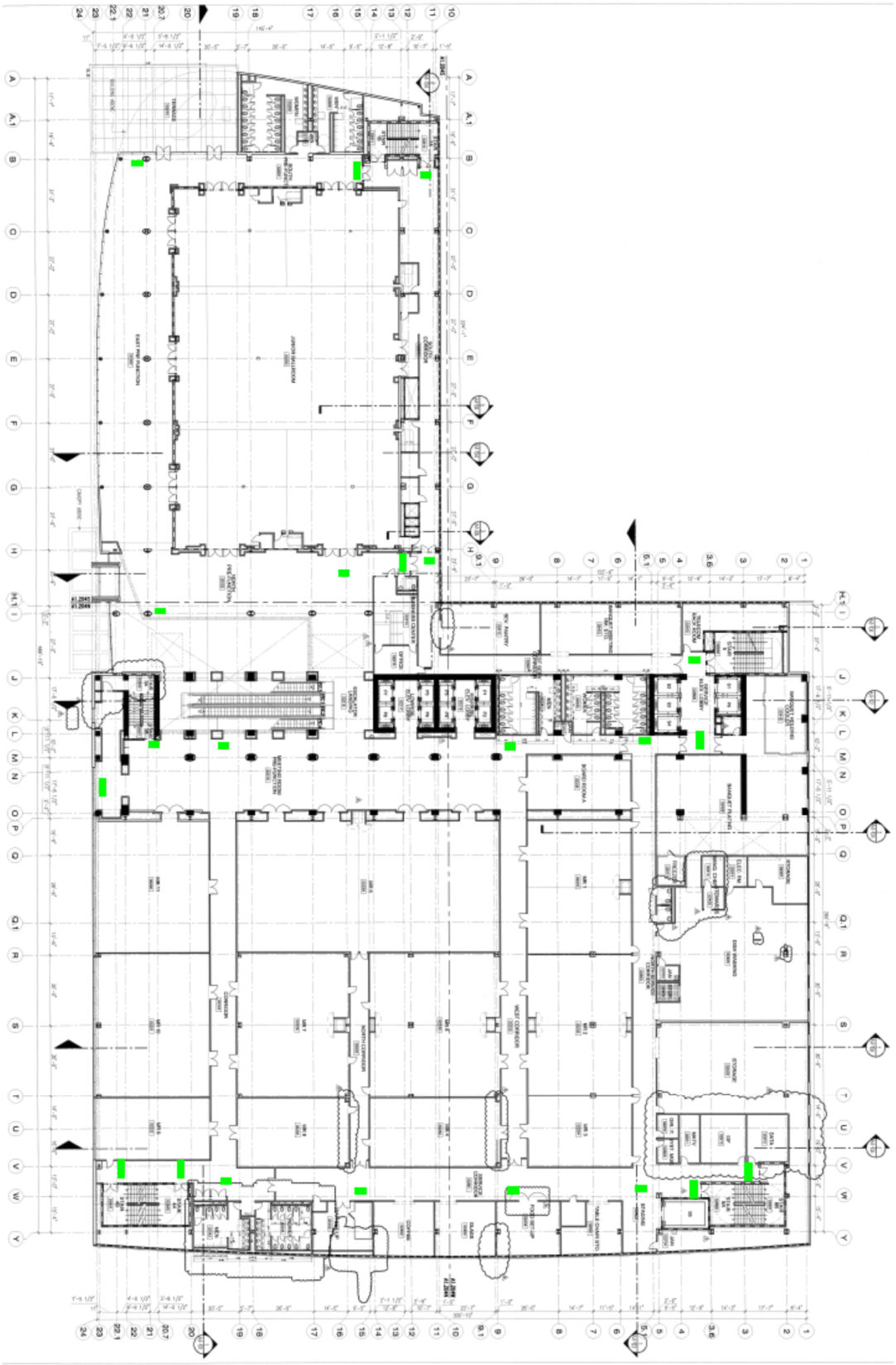


Figure 41: Level 2

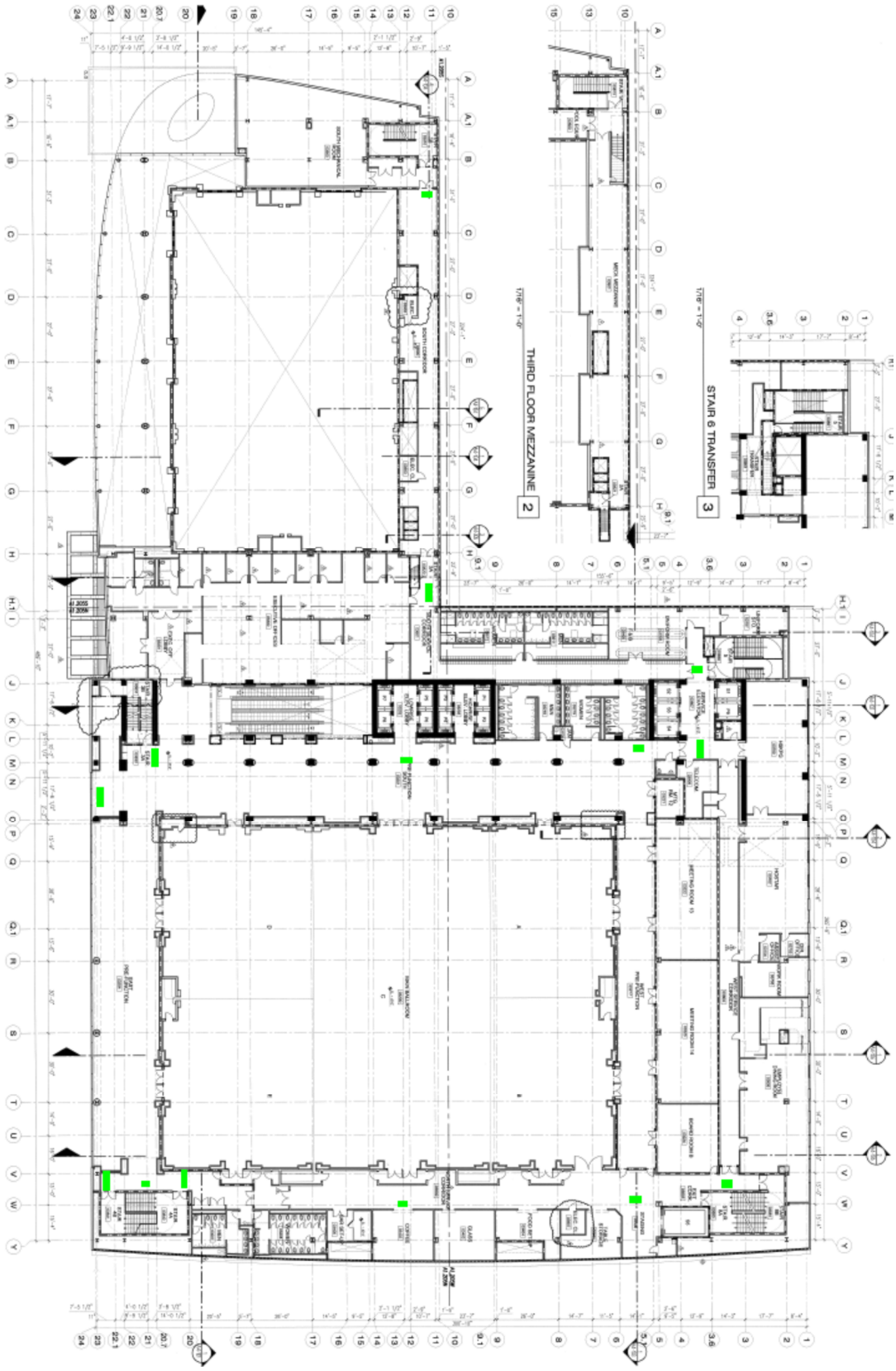


Figure 42: Level 3

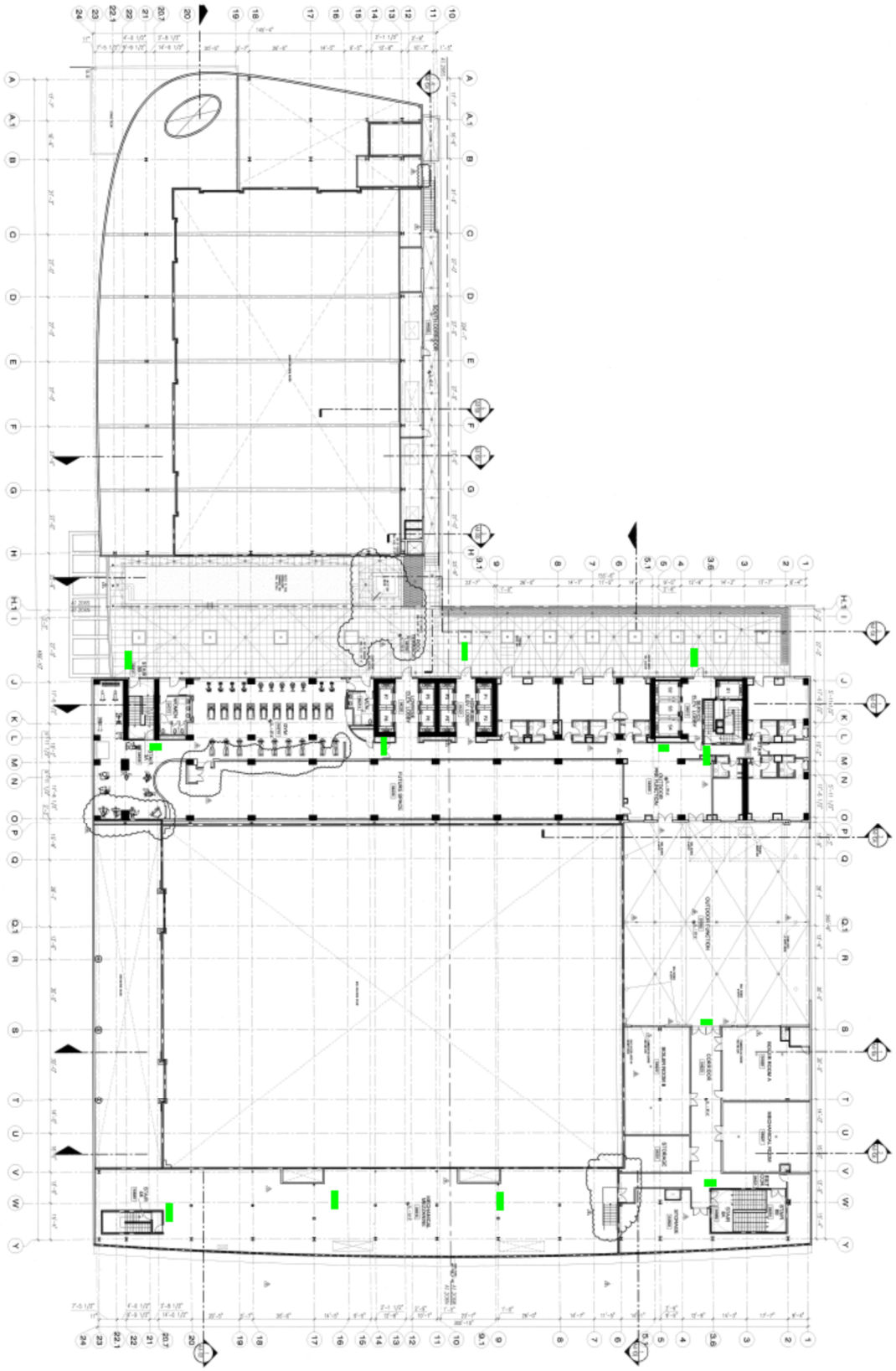


Figure 43: Level 4

Appendix F: Fire input values and results

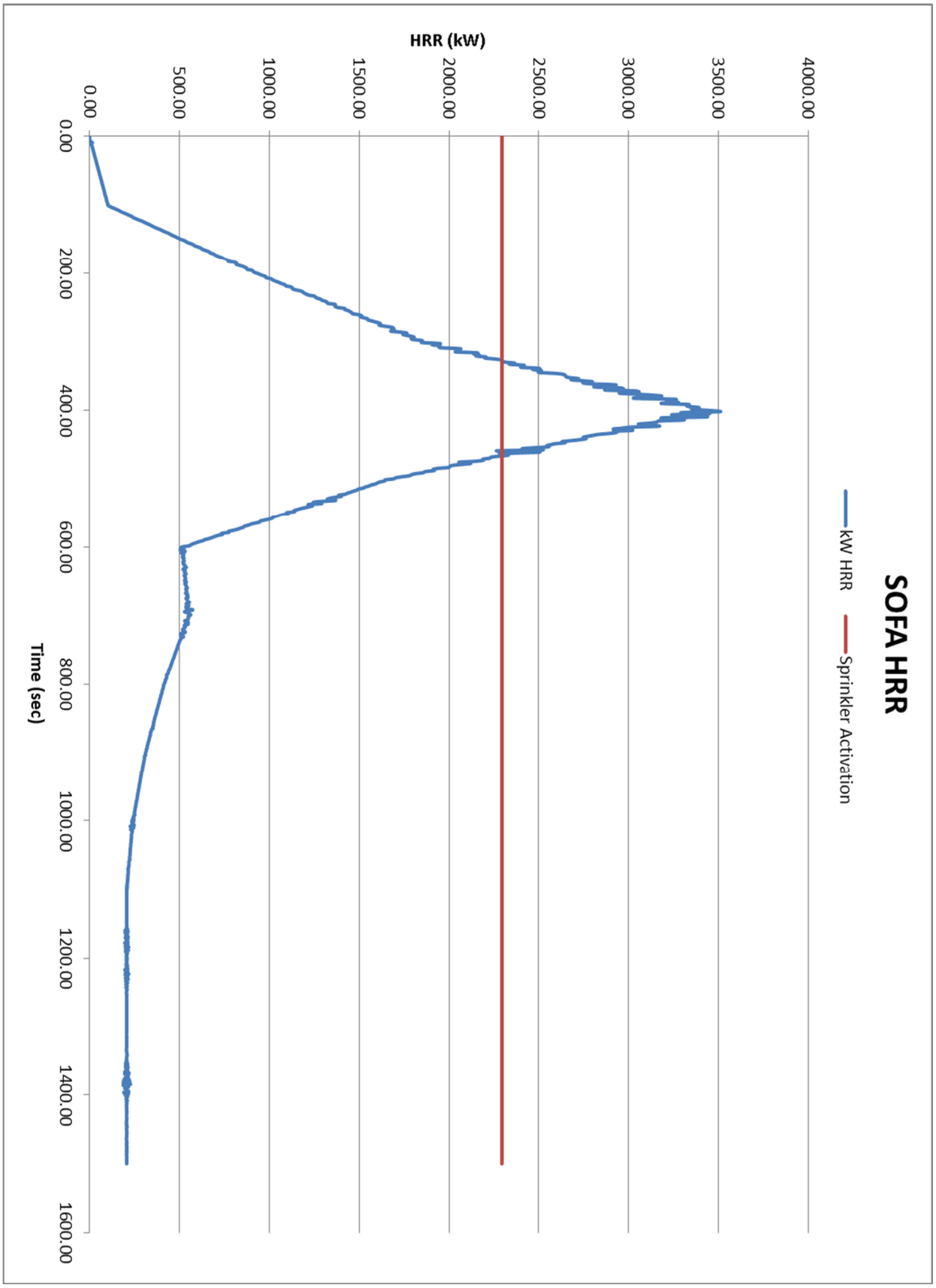
Fire Scenario 1: Couch Lobby Fire

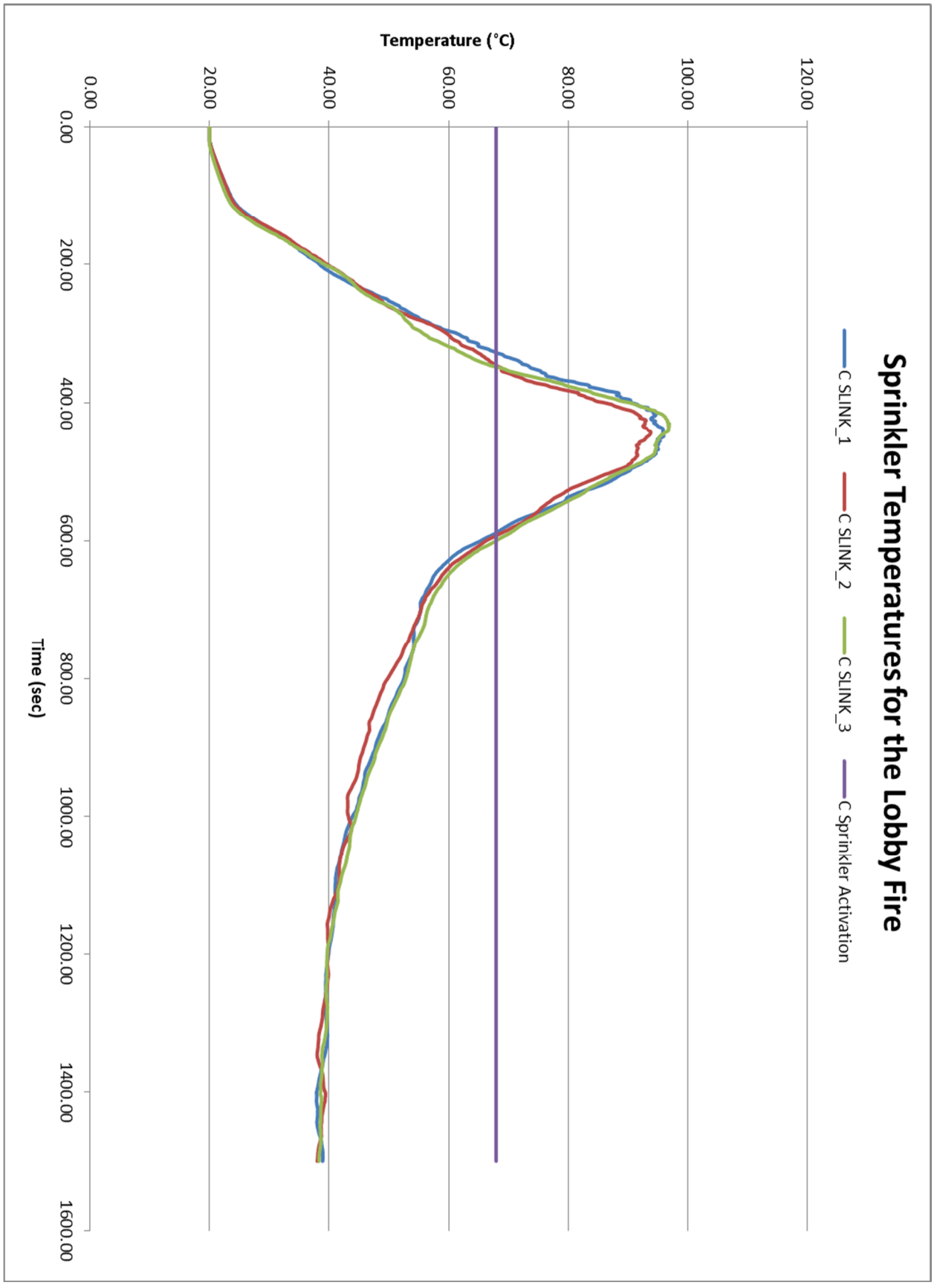
Input fire for the Fire Dynamic Simulator (FDS) Program HRR section

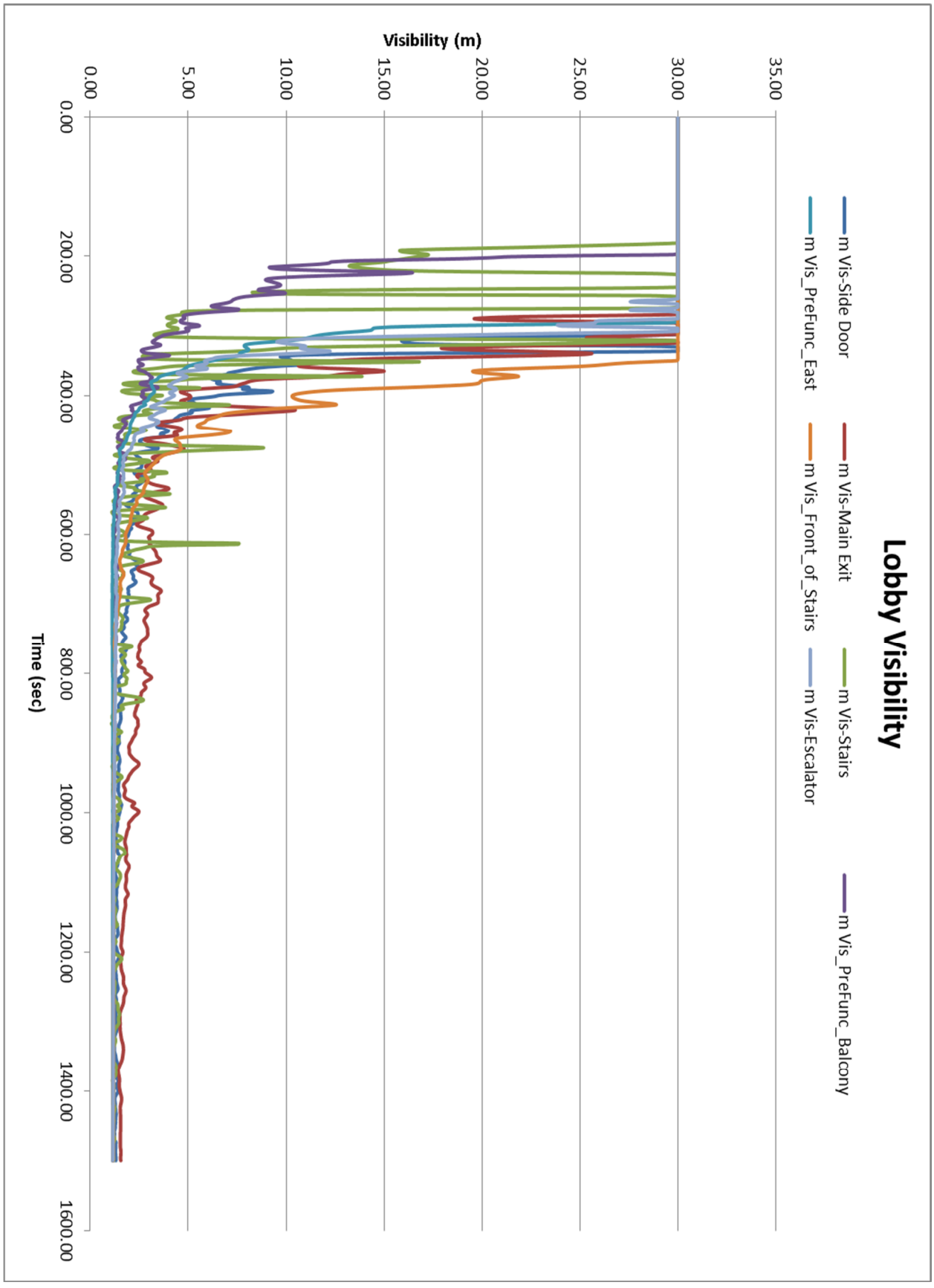
```
&REAC ID='POLYURETHANE',
    FYI='NFPA Babrauskas',
    C=6.3,
    H=7.1,
    O=2.1,
    N=1.0,
    SOOT_YIELD=0.1/

&MATL ID='FOAM',
    FYI='Caution: Reaction Rate Not Validated, remaining data from Jukka Hietaniemi, et al., "FDS simulation of fire spread...'",
    SPECIFIC_HEAT=1.7,
    CONDUCTIVITY=0.05,
    DENSITY=28.0,
    HEAT_OF_COMBUSTION=2.54E4,
    N_REACTIONS=1,
    HEAT_OF_REACTION=1750.0,
    NU_FUEL=1.0,
    REFERENCE_TEMPERATURE=350.0/

&SURF ID='Couch',
    RGB=146,202,166,
    MATL_ID(1,1)='FOAM',
    MATL_MASS_FRACTION(1,1)=1.0,
    THICKNESS(1)=0.002/
&SURF ID='Burner',
    FYI='Couch Fire',
    COLOR='RED',
    HRRPUA=6894.0,
    RAMP_Q='Burner_RAMP_Q'/
&RAMP ID='Burner_RAMP_Q', T=0.0, F=0.0/
&RAMP ID='Burner_RAMP_Q', T=100.0, F=0.03/
&RAMP ID='Burner_RAMP_Q', T=200.0, F=0.27/
&RAMP ID='Burner_RAMP_Q', T=300.0, F=0.54/
&RAMP ID='Burner_RAMP_Q', T=400.0, F=1.0/
&RAMP ID='Burner_RAMP_Q', T=500.0, F=0.48/
&RAMP ID='Burner_RAMP_Q', T=600.0, F=0.15/
&RAMP ID='Burner_RAMP_Q', T=700.0, F=0.16/
&RAMP ID='Burner_RAMP_Q', T=800.0, F=0.12/
&RAMP ID='Burner_RAMP_Q', T=900.0, F=0.09/
&RAMP ID='Burner_RAMP_Q', T=1000.0, F=0.07/
&RAMP ID='Burner_RAMP_Q', T=1100.0, F=0.06/
```


SOFA HRR
HRR (kW)
Time (sec)
kW HRR
Sprinkler Activation
0.00
500.00
1000.00
1500.00
2000.00
2500.00
3000.00
3500.00
4000.00
0.00
200.00
400.00
600.00
800.00
1000.00
1200.00
1400.00
1600.00


Sprinkler Temperatures for the Lobby Fire
C SLINK_1
C SLINK_2
C SLINK_3
C Sprinkler Activation
Temperature (°C)
120.00
100.00
80.00
60.00
40.00
20.00
0.00
0.00
200.00
400.00
600.00
800.00
1000.00
1200.00
1400.00
1600.00
Time (sec)


Lobby Visibility
m Vis-Side Door
m Vis-Main Exit
m Vis-Stairs
m Vis_PreFunc_Balcony
m Vis_PreFunc_East
m Vis_Front_of_Stairs
m Vis-Escalator
Visibility (m)
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
Time (sec)
0.00
200.00
400.00
600.00
800.00
1000.00
1200.00
1400.00
1600.00

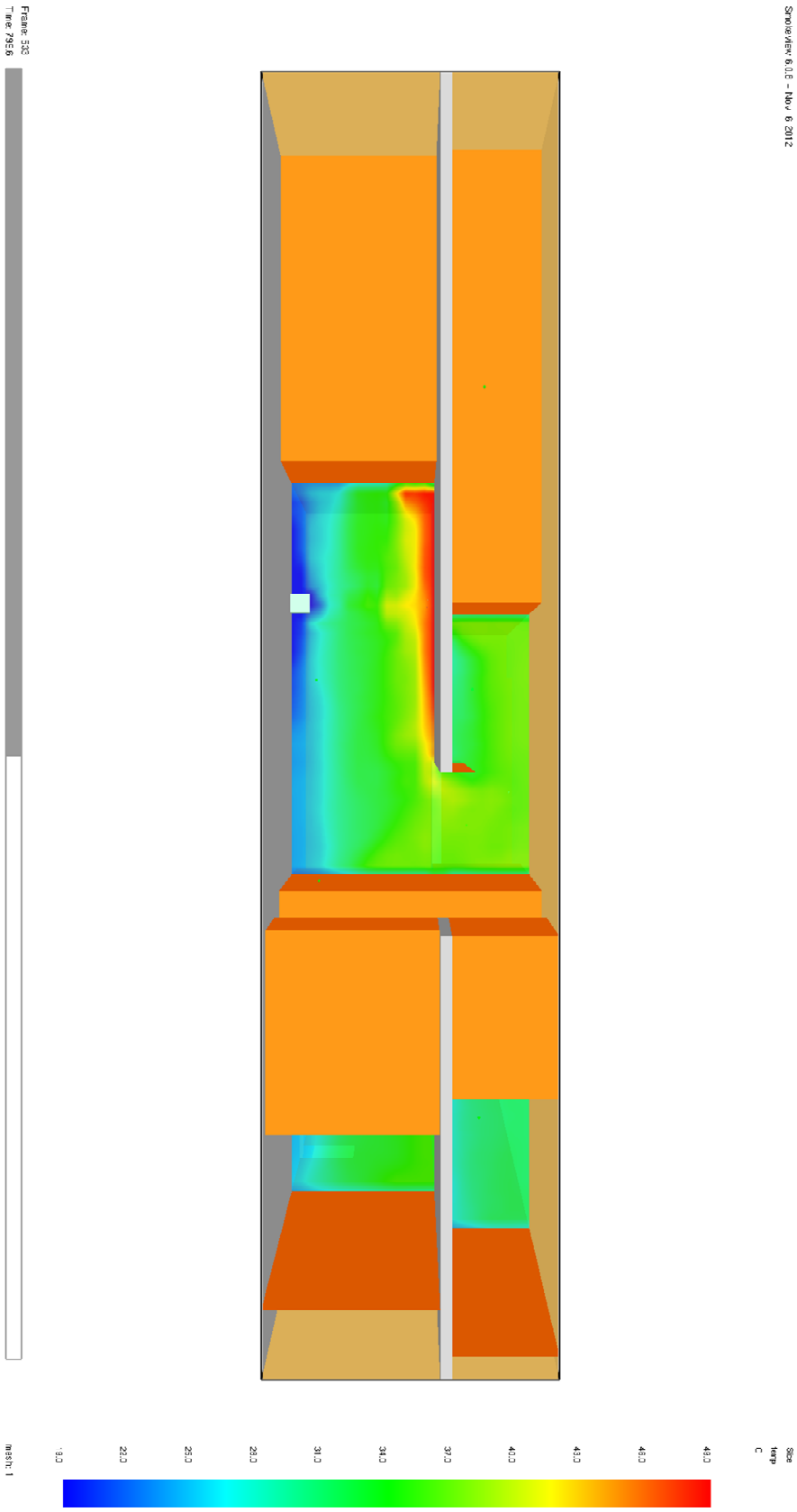


Figure 44: Temperature Slice

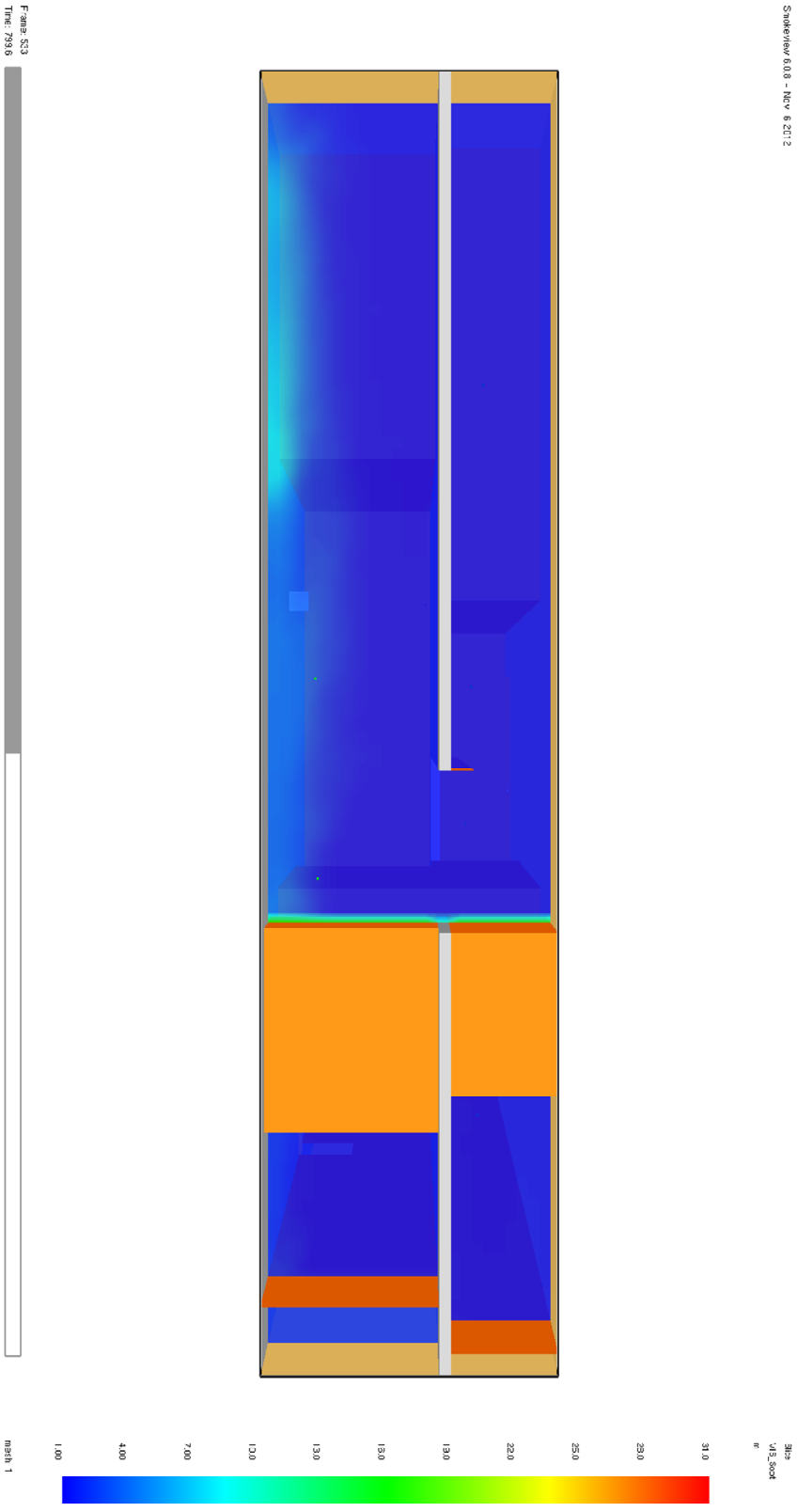
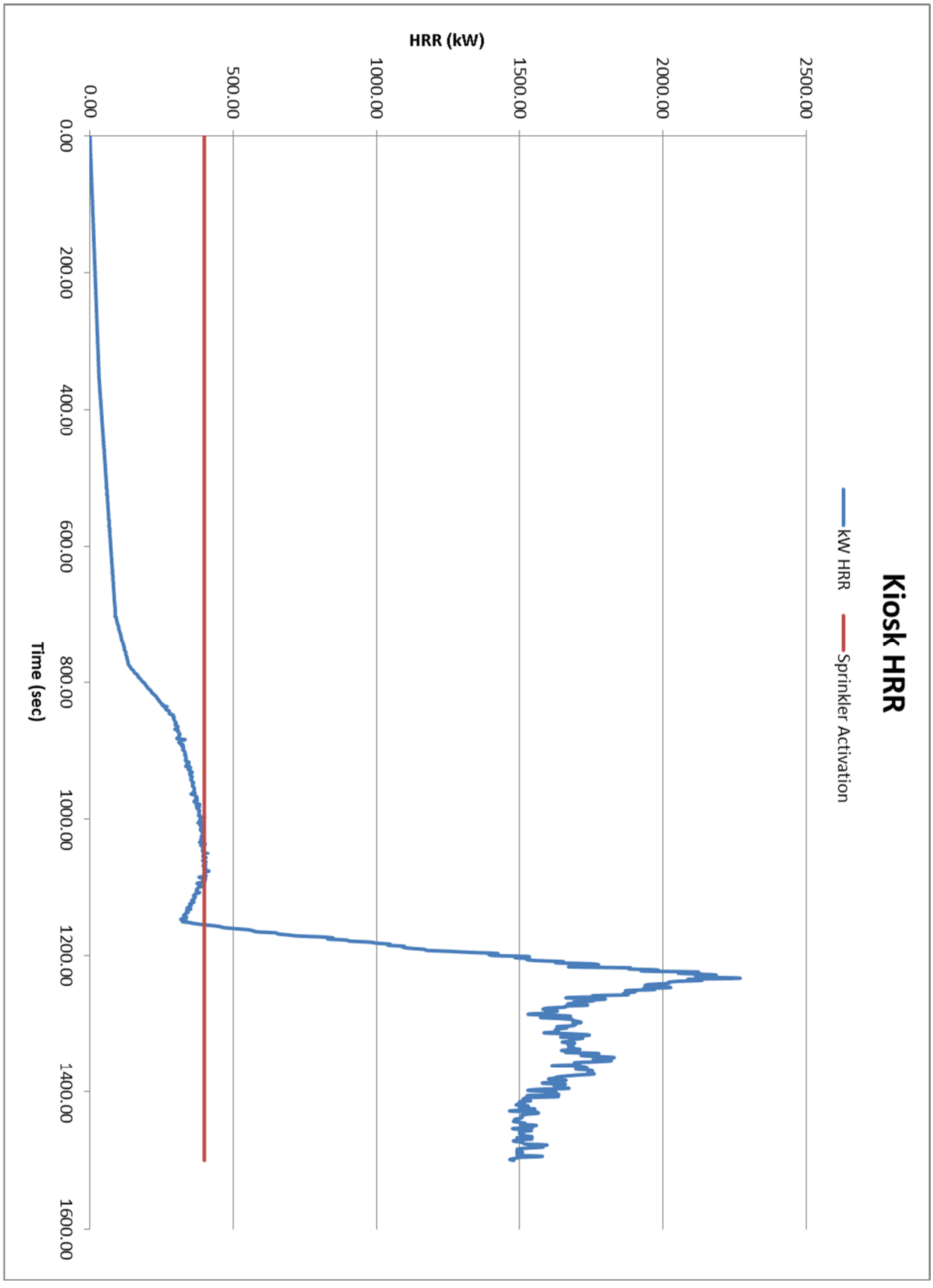


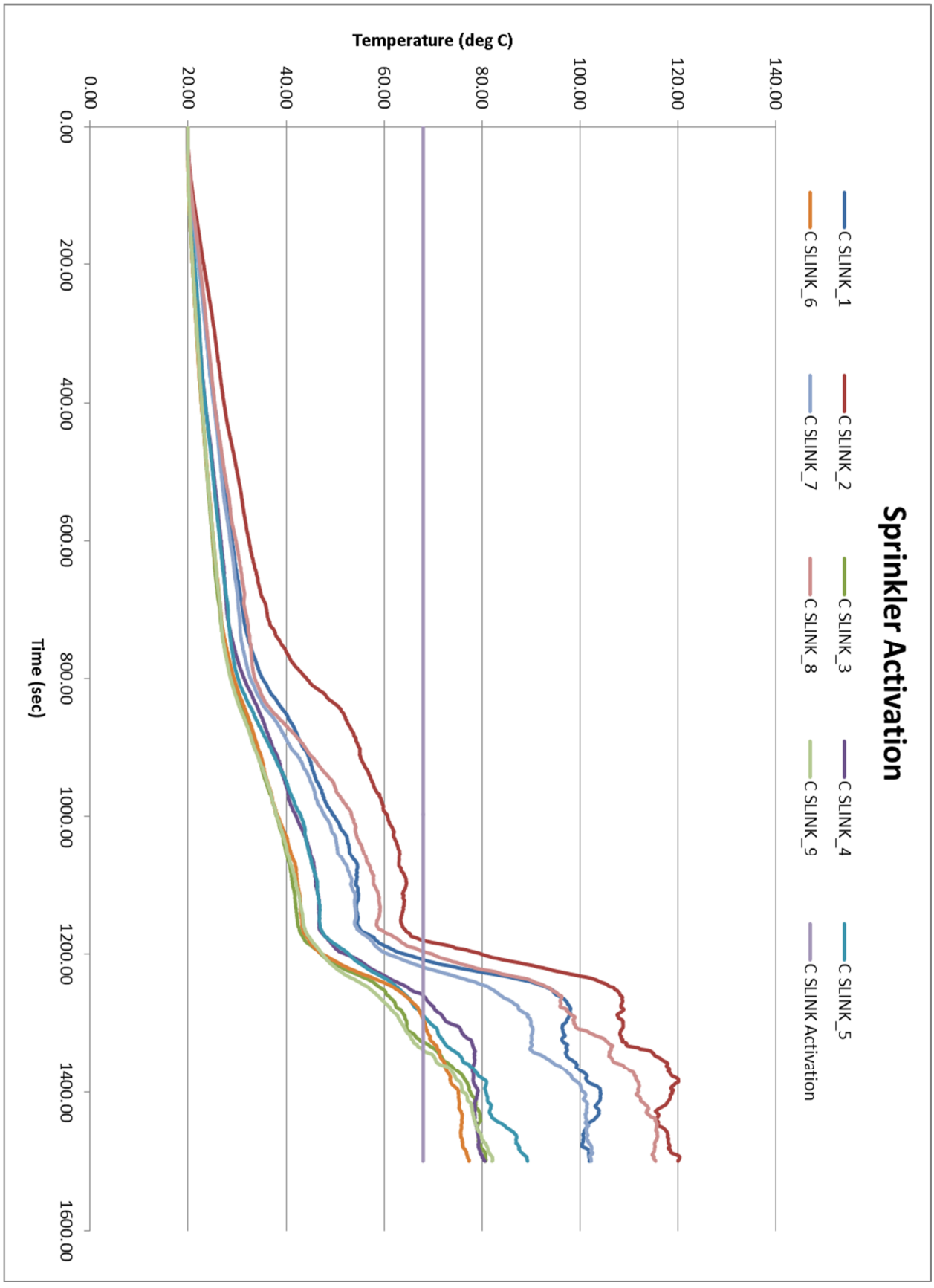
Figure 45: Visibility Slice

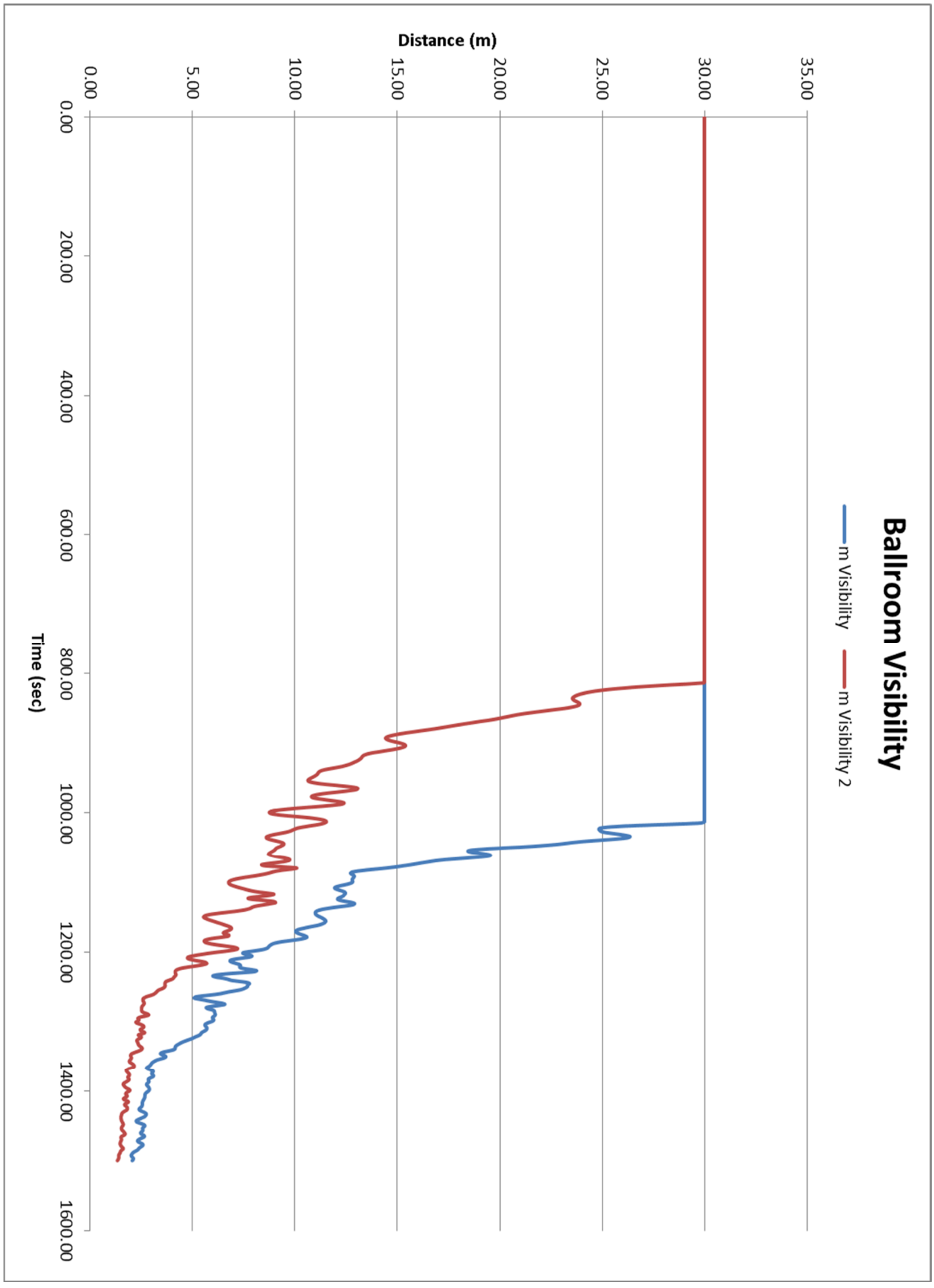
Fire Scenario 2: Ballroom Kiosk Fire

Input File for the Fire Dynamic Simulation (FDS) program HRR section

```
&SURF ID='Kiosk',
      RGB=146.0,202.0,166.0,
      HRRPUA=100.0,
      IGNITION_TEMPERATURE=343.0,
      BACKING='VOID',
      MATL_ID(1,1)='Kiosk',
      MATL_MASS_FRACTION(1,1)=1.0,
      THICKNESS(1)=0.012,
      GEOMETRY='CARTESIAN',
      LENGTH=0.0,
      WIDTH=0.0/
&SURF ID='Burner',
      COLOR='RED',
      HRRPUA=3500.0,
      RAMP_Q='Burner_RAMP_Q2',
      EMISSIVITY=0.35,
      CONVECTIVE_HEAT_FLUX=2275.0/
&RAMP ID='Burner_RAMP_Q2', T=0.0, F=0.0/
&RAMP ID='Burner_RAMP_Q2', T=350.0, F=0.018/
&RAMP ID='Burner_RAMP_Q2', T=700.0, F=0.051/
&RAMP ID='Burner_RAMP_Q2', T=775.0, F=0.078/
&RAMP ID='Burner_RAMP_Q2', T=851.0, F=0.168/
&RAMP ID='Burner_RAMP_Q2', T=927.0, F=0.199/
&RAMP ID='Burner_RAMP_Q2', T=1000.0, F=0.221/
&RAMP ID='Burner_RAMP_Q2', T=1080.0, F=0.23/
&RAMP ID='Burner_RAMP_Q2', T=1150.0, F=0.185/
&RAMP ID='Burner_RAMP_Q2', T=1230.0, F=1.0/
&RAMP ID='Burner_RAMP_Q2', T=1260.0, F=0.737/
&RAMP ID='Burner_RAMP_Q2', T=1280.0, F=0.68/
&RAMP ID='Burner_RAMP_Q2', T=1350.0, F=0.76/
&RAMP ID='Burner_RAMP_Q2', T=1420.0, F=0.617/
&RAMP ID='Burner_RAMP_Q2', T=1480.0, F=0.629/
&RAMP ID='Burner_RAMP_Q2', T=1550.0, F=0.571/
&RAMP ID='Burner_RAMP_Q2', T=1620.0, F=0.72/
&RAMP ID='Burner_RAMP_Q2', T=1680.0, F=0.558/
&RAMP ID='Burner_RAMP_Q2', T=1750.0, F=0.46/
&RAMP ID='Burner_RAMP_Q2', T=2270.0, F=0.302/
&RAMP ID='Burner_RAMP_Q', T=0.0, F=0.0/
&RAMP ID='Burner_RAMP_Q', T=350.0, F=0.018/
&RAMP ID='Burner_RAMP_Q', T=700.0, F=0.051/
&RAMP ID='Burner_RAMP_Q', T=775.0, F=0.078/
&RAMP ID='Burner_RAMP_Q', T=851.0, F=0.168/
&RAMP ID='Burner_RAMP_Q', T=927.0, F=0.199/
&RAMP ID='Burner_RAMP_Q', T=1000.0, F=0.221/
&RAMP ID='Burner_RAMP_Q', T=1080.0, F=0.23/
&RAMP ID='Burner_RAMP_Q', T=1150.0, F=0.185/
&RAMP ID='Burner_RAMP_Q', T=1230.0, F=1.0/
&RAMP ID='Burner_RAMP_Q', T=1260.0, F=0.737/
&RAMP ID='Burner_RAMP_Q', T=1280.0, F=0.68/
&RAMP ID='Burner_RAMP_Q', T=1350.0, F=0.76/
&RAMP ID='Burner_RAMP_Q', T=1420.0, F=0.617/
&RAMP ID='Burner_RAMP_Q', T=1480.0, F=0.629/
&RAMP ID='Burner_RAMP_Q', T=1550.0, F=0.571/
&RAMP ID='Burner_RAMP_Q', T=1620.0, F=0.72/
&RAMP ID='Burner_RAMP_Q', T=1680.0, F=0.558/
&RAMP ID='Burner_RAMP_Q', T=1750.0, F=0.46/
&RAMP ID='Burner_RAMP_Q', T=2270.0, F=0.302/
```


Kiosk HRR
HRR (kW)
0.00
500.00
1000.00
1500.00
2000.00
2500.00
kW HRR
Sprinkler Activation
Time (sec)
0.00
200.00
400.00
600.00
800.00
1000.00
1200.00
1400.00
1600.00


Sprinkler Activation
Temperature (deg C)
Time (sec)
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
0.00
200.00
400.00
600.00
800.00
1000.00
1200.00
1400.00
1600.00
C SLINK_1
C SLINK_2
C SLINK_3
C SLINK_4
C SLINK_5
C SLINK_6
C SLINK_7
C SLINK_8
C SLINK_9
C SLINK Activation


Ballroom Visibility
m Visibility
m Visibility 2
Distance (m)
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
Time (sec)
0.00
200.00
400.00
600.00
800.00
1000.00
1200.00
1400.00
1600.00

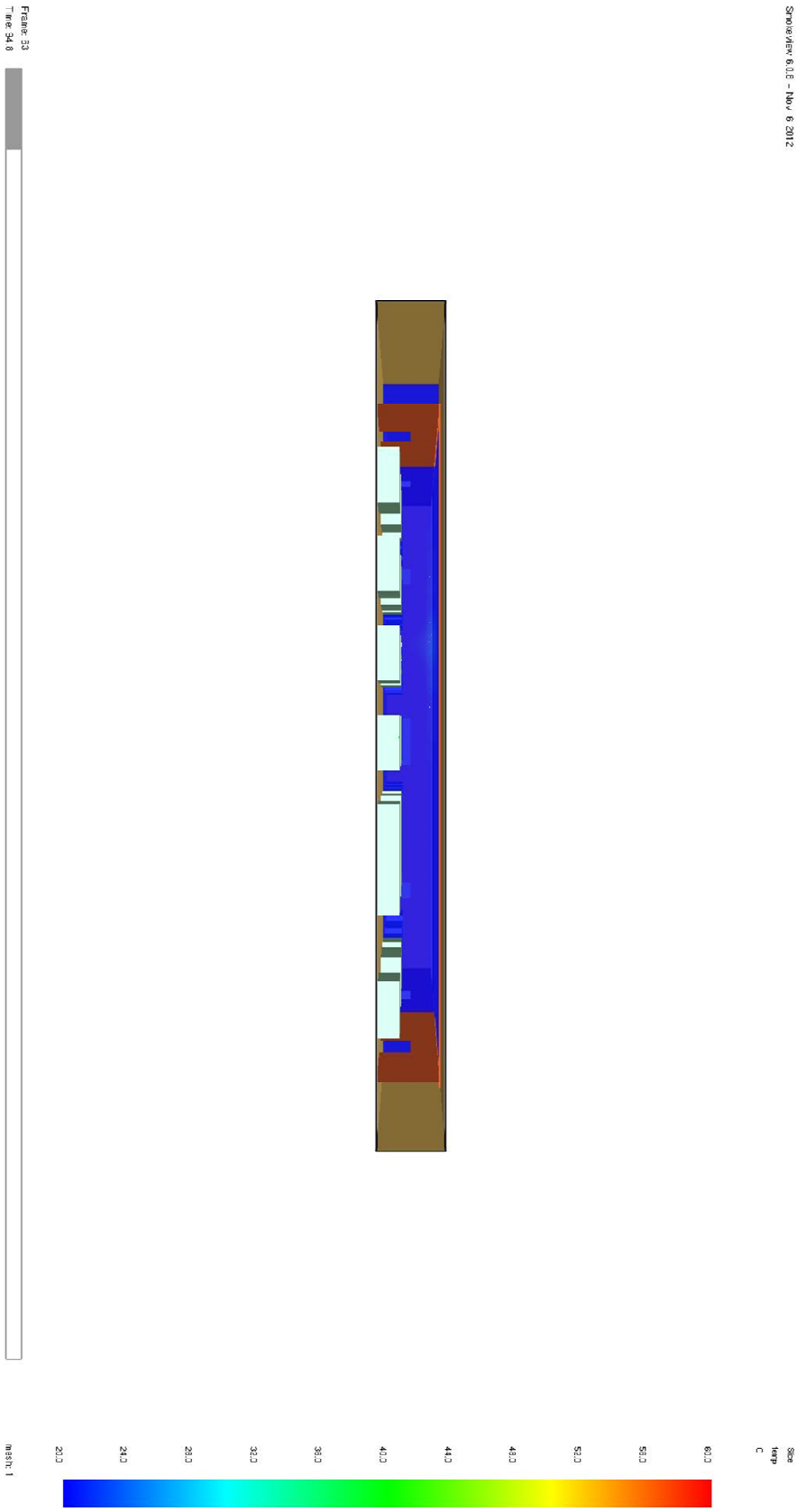


Figure 46: Temperature Slice at 94 seconds

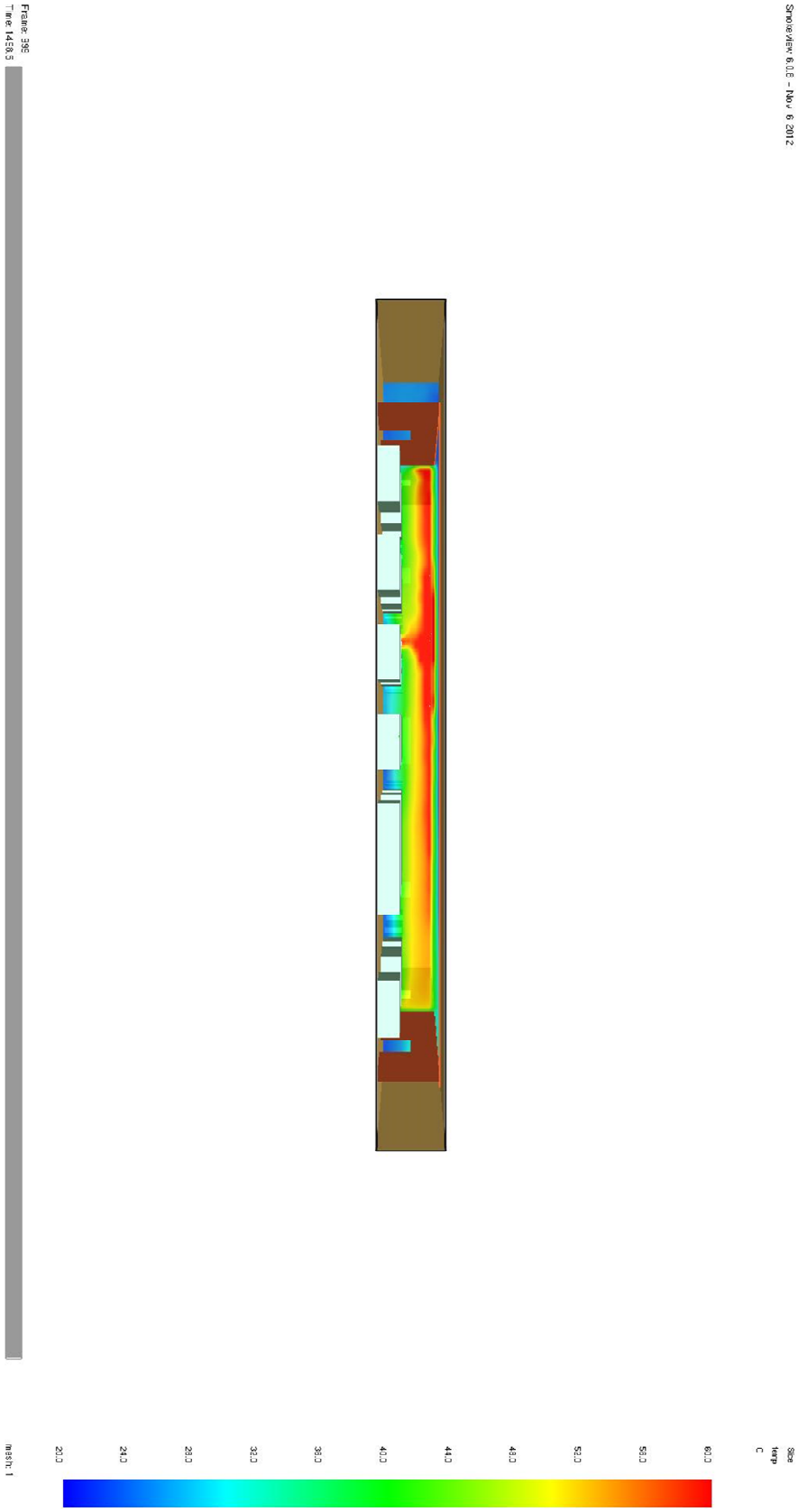


Figure 47: Temperature Slice at 1500 seconds

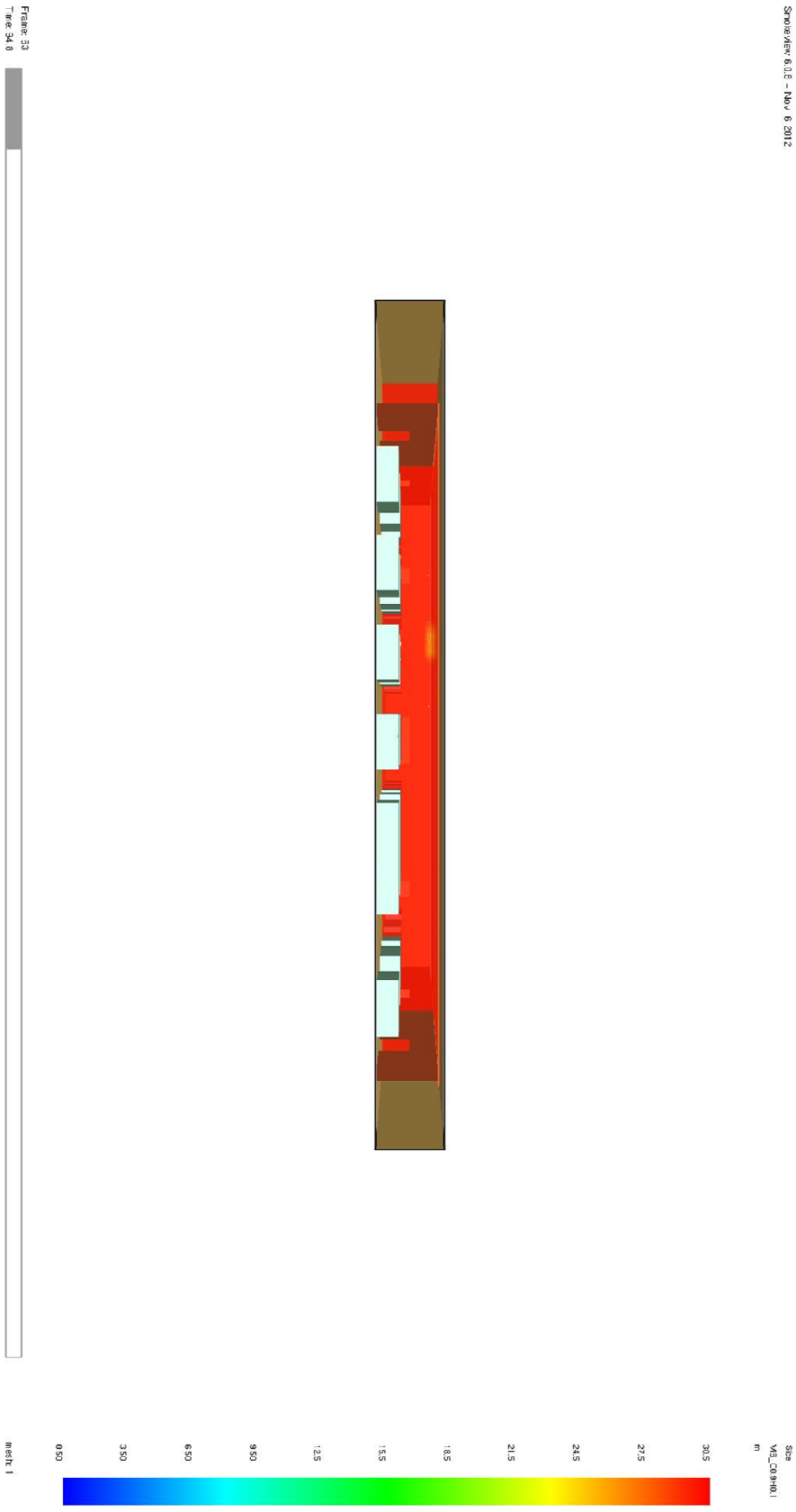


Figure 48: Visibility Slice at 94 seconds

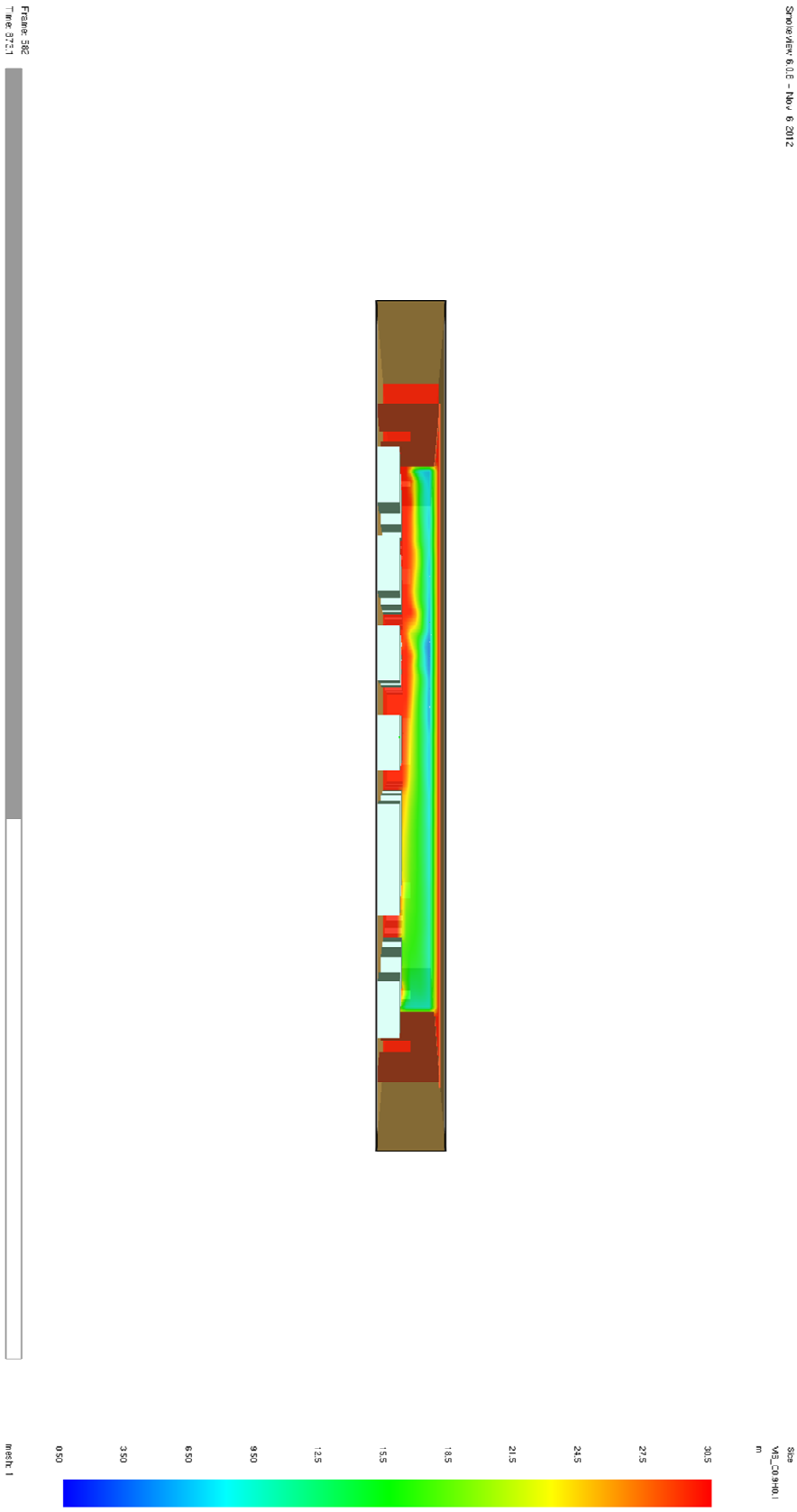


Figure 49: Visibility Slice at 873 seconds

Fire Dynamic Simulator (FDS) Grid Resolution

As a first approximation for the necessary grid cell size to accomplish proper resolution of the turbulent flow, it is generally recommended that the cell size in close proximity to the fire defined by the following equation[1]:

$$D^* = \left(\frac{\dot{Q}}{\rho_\infty c_p T_\infty \sqrt{g}}\right)^{2/5}$$

Where:

$\dot{Q}$ = Total heat release rate of the fire (kW)
ρ_∞ = Density of ambient air
c_p = Specific heat of ambient air
c_p = Temperature of ambient air
g = Gravitational acceleration

$$D^* = \left(\frac{\dot{Q}}{1{,}100}\right)^{2/5}$$

Grid sizes in close proximity to the fire should be no larger than one-fifth the size of D*. The following table outlines the maximum grid size that could be used to accurately analyze each fire.

Fire Size	D*	Mesh
3,447 kW (Couch Fire)	1.573	0.39
1,745 kW (Kiosk Fire)	1.198	0.30

In the analysis, a mesh of 0.30 m was used.

It was determined that this mesh would be adequate for verification of the tenability visibility and temperatures.

[1] Kevin B. McGrattan, Glenn P. Forney, *"Fire Dynamics Simulator – User's Manual"*, National Institute of Standards and Technology, Gaithersburg, MD., NISTIR 6469, January 2000.

Full Scale Drawings of the Sheraton Hotel

Sheraton Phoenix Downtown HOTEL

DOWNTOWN PHOENIX HOTEL CORPORATION

TynanGroup Real Estate Development Services

3D/I

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602.468.0505 tel

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Englewood, CO 80111
303.771.0034 tel

LIFE SAFETY / ADA:
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602.685.1077 tel

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4528 Mc Kinney Ave., Suite 106
Dallas, TX 75205
214.780.0700 tel

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602.495.1260 tel

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12525 Lambert Road
Whittier, CA 90606
310.877.6776 tel

ARQUITECTONICA PROJECT NO. : 002297.00

KEY PLAN

SEAL / SIGNATURE / DATE — STATE OF ARIZONA

SERGIO S. BAKAS - AIA #43444

CONSTRUCTION DOCUMENTS
PERMIT # LPRN-06004
QS: 11-28 SDEV: 0500952 DSD KIVA: 05-2376

Issue #	Issue Date / For
1	07.14.2006 / PERMIT SET
2	10.26.2006 / PERMIT RESUBMISSION
3	11.17.2006 / CONSTRUCTION SET
4	09.14.2007 / 8

SHEET INDEX

GROUND FLOOR (0'-0")

SCALE : SEE PLAN

SHEET NO.

A1.103

1 SECOND FLOOR (25'-00")

1/16" = 1'-0"

N

FIRE RESISTANCE RATING DESIGNATION

1 HR.

2 HR.

3 HR.

Sheraton Phoenix Downtown HOTEL

DOWNTOWN PHOENIX HOTEL CORPORATION

TynanGroup Real Estate Development Services

3D/I

ARCHITECT OF RECORD:

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AUDIO VISUAL - ACOUSTICAL:

VSA

12525 Lambert Road
Whittier, CA 90606
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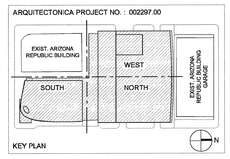
ARQUITECTONICA PROJECT NO. : 002297.00



KEY PLAN

SEAL / SIGNATURE / DATE STATE OF ARIZONA

SERGIO S. BAKAS - AIA #43444

CONSTRUCTION DOCUMENTS
PERMIT # LPRN-06004
QS: 11-28 SDEV: 0500952 DSD KIVA: 05-2376

Issue #	Issue Date / For
1	07.14.2006 / PERMIT SET
2	10.26.2006 / PERMIT RESUBMISSION
3	11.17.2006 / CONSTRUCTION SET
4	09.14.2007 / . /8.

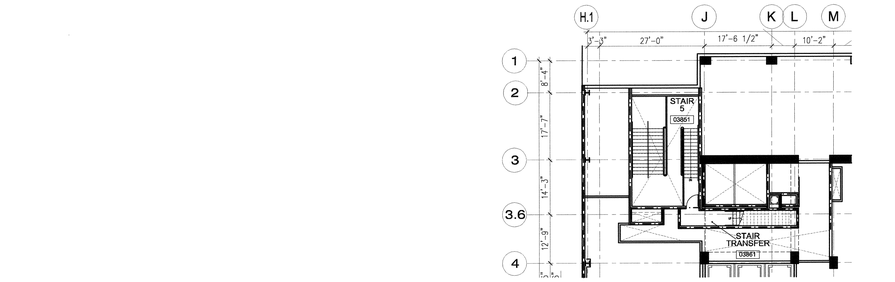
SHEET INDEX

SECOND FLOOR (25'-0")

SCALE : SEE PLAN

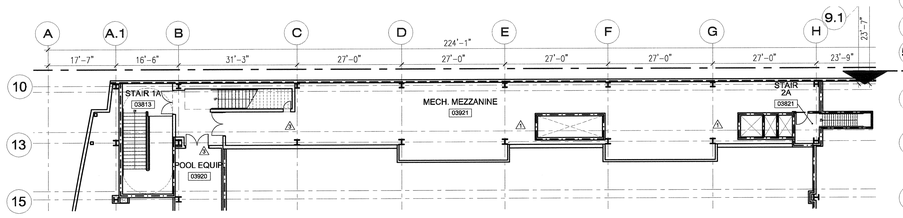
SHEET NO.

A1.104



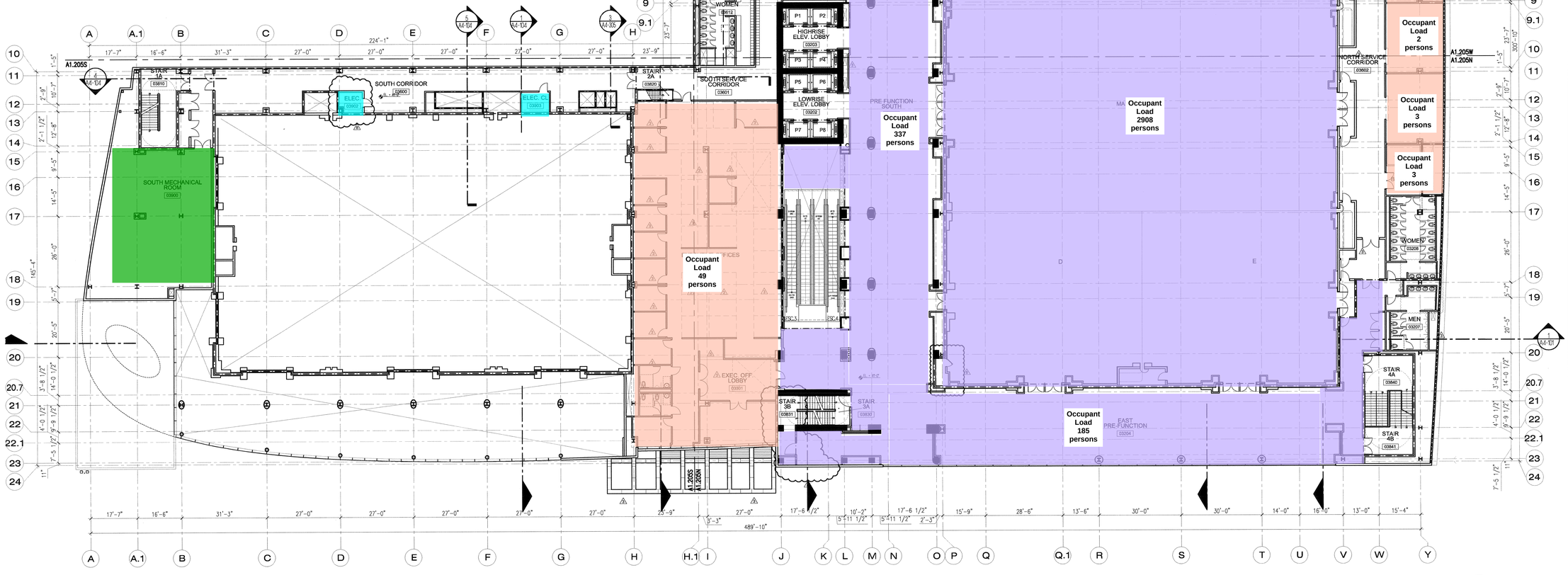
STAIR 6 TRANSFER 3

1/16" = 1'-0"



THIRD FLOOR MEZZANINE 2

1/16" = 1'-0"



THIRD FLOOR (41'-00") 1

1/16" = 1'-0"

FIRE RESISTANCE RATING DESIGNATION

1 HR. ---

2 HR. -·-·-

3 HR. -··-··-

Sheraton Phoenix Downtown HOTEL

DOWNTOWN PHOENIX HOTEL CORPORATION

TynanGroup Real Estate Development Services

3D/I

ARCHITECT OF RECORD:

ARQUITECTONICA

801 Brickell Ave, Suite 1100
Miami, Florida 33131
305.372.1812 tel.
www.arquitectonica.com

ASSOCIATE ARCHITECT:

RSP ARCHITECTS

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INTERIOR DESIGNER:

BBG-BBGM

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Scottsdale, Arizona 85255
480.538.3288 tel

CIVIL ENGINEER:

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602.678.5151 tel

STRUCTURAL ENGINEER:

Walter P. Moore & Assoc.

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Las Vegas, NV 89119
702.944.4715 tel

MEP ENGINEER:

Syska & Hennessy

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Los Angeles, CA 90064
310.312.0200 tel

LANDSCAPE ARCHITECT:

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602.468.0505 tel

FOOD SERVICES:

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5200 DTC Parkway, Suite 500
Englewood, CO 80111
303.771.0034 tel

LIFE SAFETY / ADA:

Rolf Jensen & Associates

668 North 44th Street, Suite 300
Phoenix, Arizona 85008
602.685.1077 tel

LIGHTING:

Lang Lighting

4528 Mc Kinney Ave., Suite 106
Dallas, TX 75205
214.780.0700 tel

GRAPHIC DESIGN:

Thinking Caps

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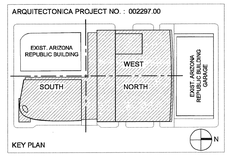
602.495.1260 tel

AUDIO VISUAL - ACOUSTICAL:

VSA

12525 Lambert Road
Whittier, CA 90606
310.877.6776 tel

ARQUITECTONICA PROJECT NO. : 002297.00



KEY PLAN

SEAL / SIGNATURE / DATE STATE OF ARIZONA

SERGIO S. BAKAS - AIA #43444

CONSTRUCTION DOCUMENTS

PERMIT # LPRN-06004

QS: 11-28 SDEV: 0500952 DSD KIVA: 05-2376

Issue #	Issue Date / For
1	07.14.2006 / PERMIT SET
2	10.26.2006 / PERMIT RESUBMISSION
3	11.17.2006 / CONSTRUCTION SET
4	09.14.2007 / .

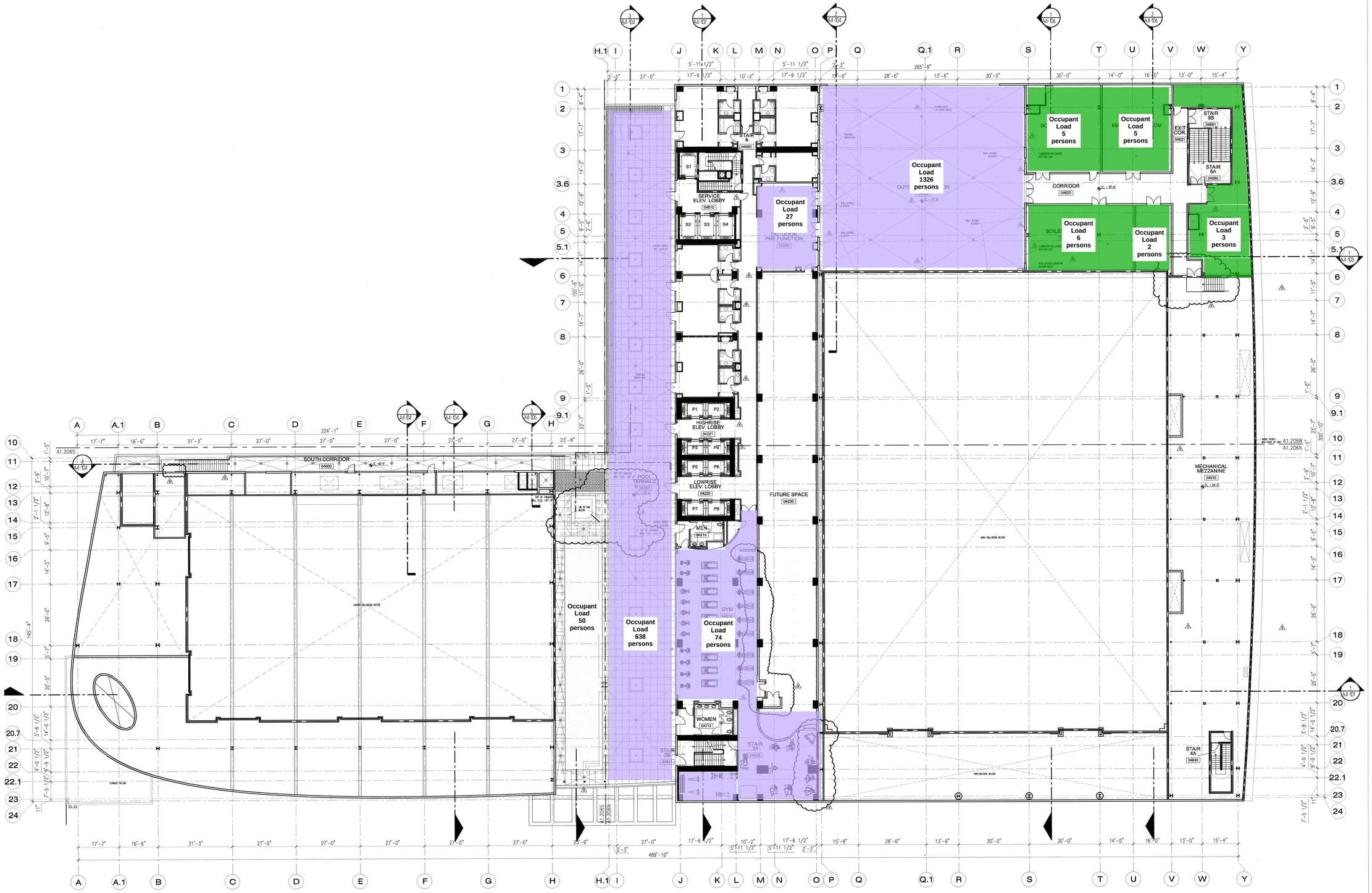
SHEET INDEX

THIRD FLOOR (41'-0")

SCALE : SEE PLAN

SHEET NO.

A1.105



FOURTH FLOOR (59'-6")
1/16" = 1'-0"

1

N

FIRE RESISTANCE RATING DESIGNATION
1 HR.
2 HR.
3 HR.

Sheraton Phoenix Downtown
HOTEL

DOWNTOWN PHOENIX HOTEL CORPORATION

TynanGroup
Real Estate Development Services

3D/I

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ARQUITECTONICA PROJECT NO. : 002297.00

KEY PLAN

SEAL / SIGNATURE / DATE — STATE OF ARIZONA

SERGIO S. BAKAS - AIA #43444

CONSTRUCTION DOCUMENTS
PERMIT # LPRN-06004
QS: 11-28 SDEV: 0500952 DSD KIVA: 05-2376

Issue #	Issue Date / For
1	07.14.2006 / PERMIT SET
2	10.26.2006 / PERMIT RESUBMISSION
3	11.17.2006 / CONSTRUCTION SET
4	09.14.2007 /

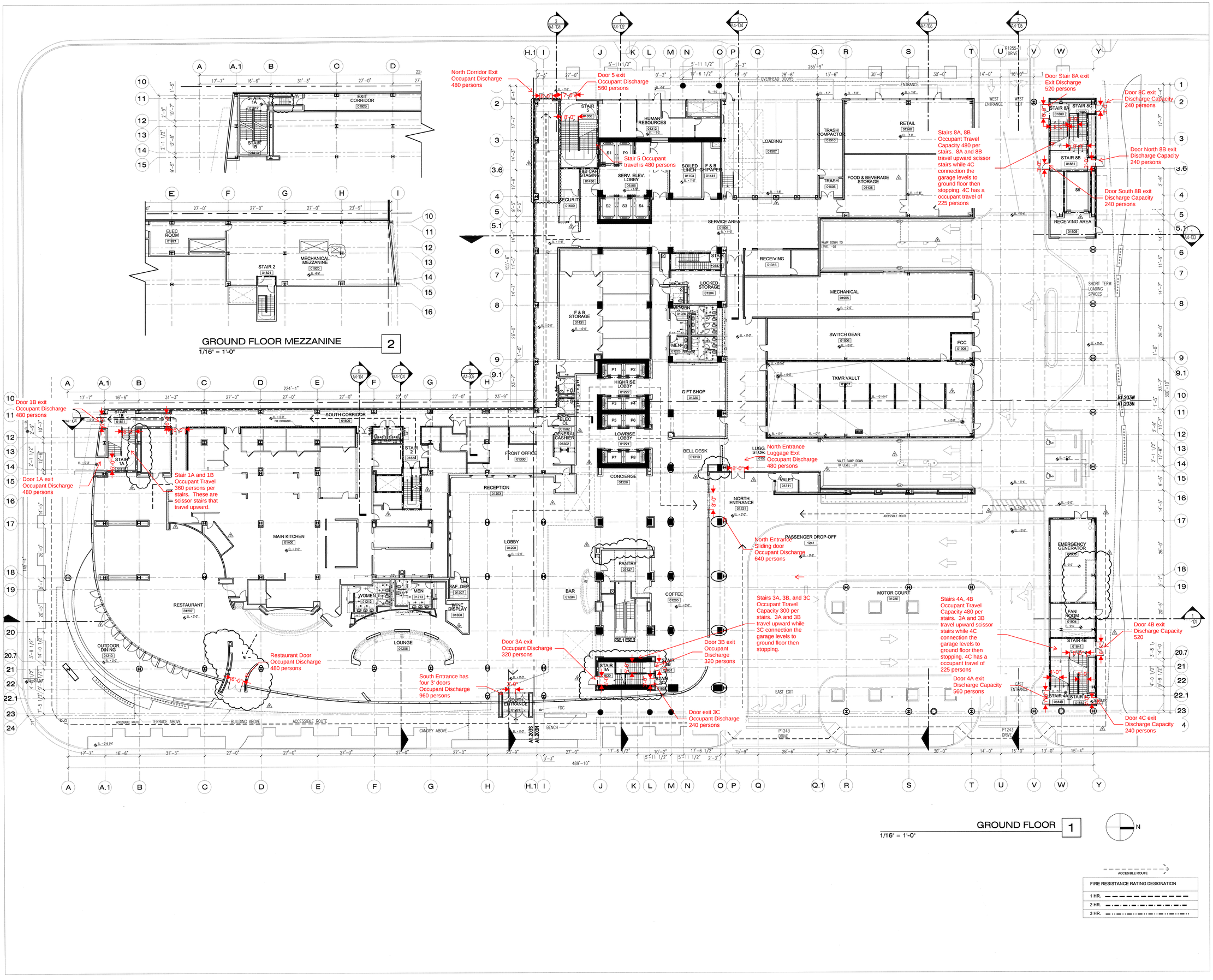
SHEET INDEX

FOURTH FLOOR (59'-6")

SCALE : SEE PLAN

SHEET NO.

A1.106



Sheraton Phoenix Downtown HOTEL

DOWNTOWN PHOENIX HOTEL CORPORATION

TynanGroup Real Estate Development Services

3D/I

ARCHITECT OF RECORD:
ARQUITECTONICA
801 Brickell Ave, Suite 1100
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GRAPHIC DESIGN:
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815 North Firth Ave.
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AUDIO VISUAL - ACOUSTICAL:
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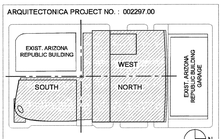
ARQUITECTONICA PROJECT NO. : 002297.00



KEY PLAN

SEAL / SIGNATURE / STATE OF ARIZONA

REGISTERED ARCHITECT SERGIO BAKAS ARIZONA U.S.A.

SERGIO S. BAKAS - AIA #43444

CONSTRUCTION DOCUMENTS
PERMIT # LPRN-06004
QS: 11-28 SDEV: 0500952 DSD KIVA: 05-2376

Issue #	Issue Date / For
1	07.14.2006 / PERMIT SET
2	10.28.2006 / PERMIT RESUBMISSION
3	11.17.2006 / CONSTRUCTION SET
4	09.14.2007 / 8

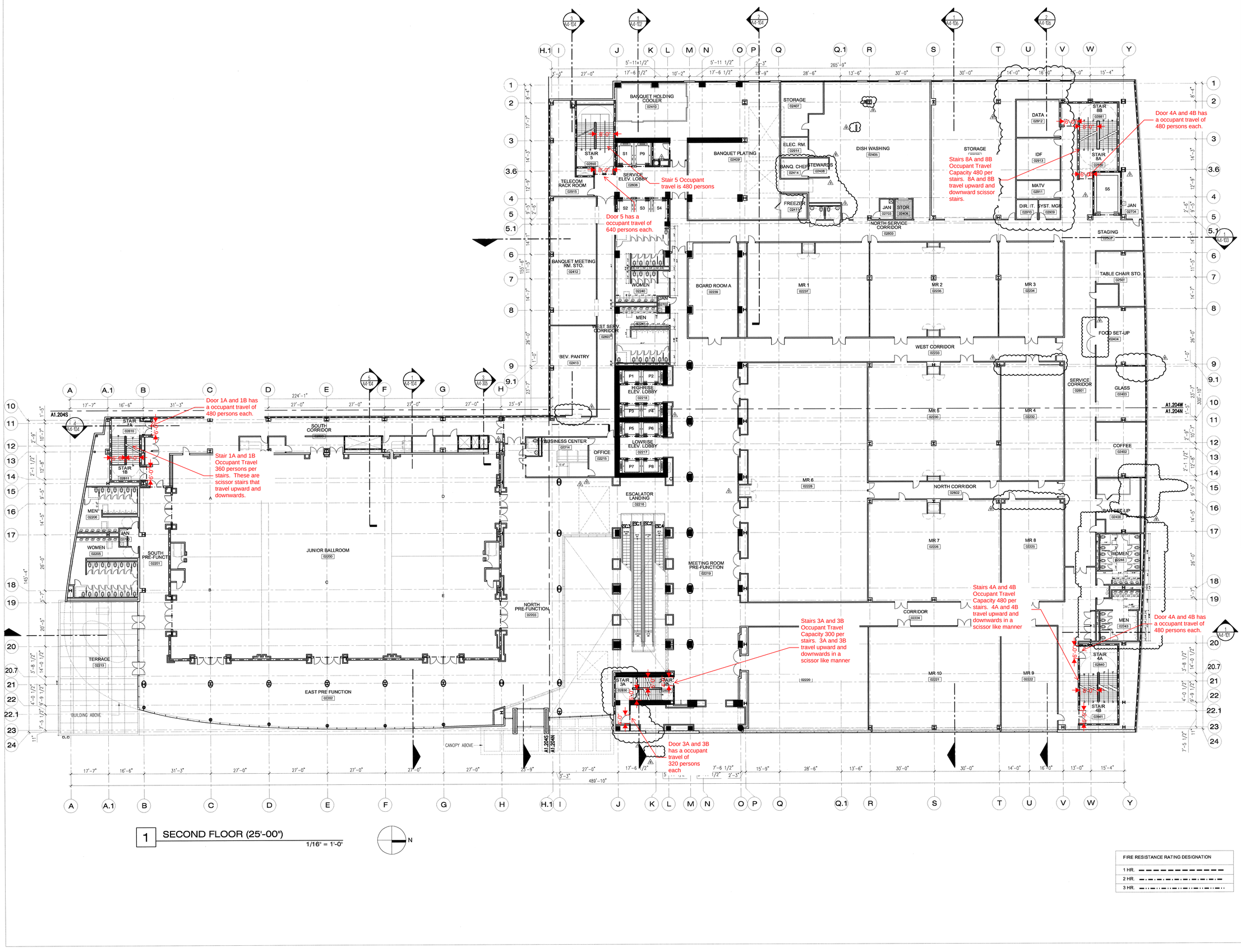
SHEET INDEX

GROUND FLOOR
(0'-0")

SCALE : SEE PLAN

SHEET NO.

A1.103



1 SECOND FLOOR (25'-00")
1/16" = 1'-0"

N

FIRE RESISTANCE RATING DESIGNATION
1 HR.
2 HR.
3 HR.

Sheraton Phoenix Downtown HOTEL

DOWNTOWN PHOENIX HOTEL CORPORATION

TynanGroup Real Estate Development Services

3D/I

ARCHITECT OF RECORD:
ARQUITECTONICA
801 Brickell Ave, Suite 1100
Miami, Florida 33131
305.372.1812 tel.
www.arquitectonica.com

ASSOCIATE ARCHITECT:
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Las Vegas, NV 89119
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310.877.6776 tel

ARQUITECTONICA PROJECT NO. : 002297.00

KEY PLAN

SEAL / SIGNATURE / DATE — STATE OF ARIZONA

SERGIO S. BAKAS - AIA #43444

CONSTRUCTION DOCUMENTS
PERMIT # LPRN-06004
QS: 11-28 SDEV: 0500952 DSD KIVA: 05-2376

Issue #	Issue Date / For
1	07.14.2006 / PERMIT SET
2	10.26.2006 / PERMIT RESUBMISSION
3	11.17.2006 / CONSTRUCTION SET
4	09.14.2007 / . /8.

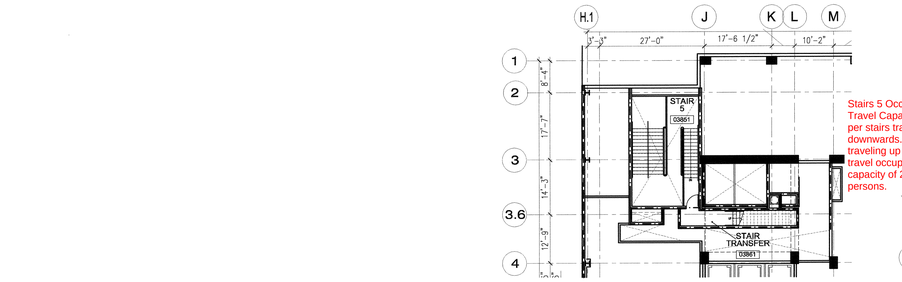
SHEET INDEX

SECOND FLOOR (25'-0")

SCALE : SEE PLAN

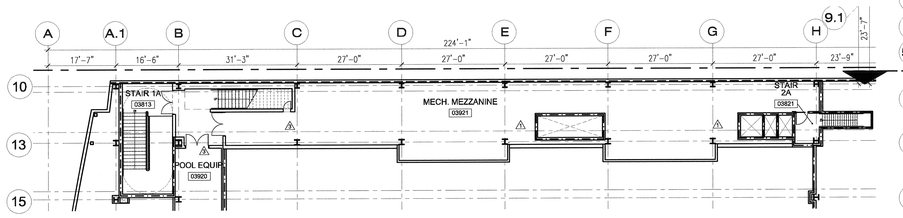
SHEET NO.

A1.104



STAIR 6 TRANSFER 3

1/16" = 1'-0"



THIRD FLOOR MEZZANINE 2

1/16" = 1'-0"

Stairs 5 Occupant Travel Capacity 480 per stairs traveling downwards. Stair 5 traveling up has a travel occupant capacity of 240 persons.

Door 5 has a occupant travel of 480 persons each.

Door 1A and 1B has a occupant travel of 480 persons each.

Stair 1A Occupant Travel 360 persons per stairs.

Stairs 3A and 3B Occupant Travel Capacity 300 per stairs. 3A and 3B travel upward and downwards in a scissor like manner

Door 3A and 3B has a occupant travel of 320 persons each

Stairs 4A and 4B Occupant Travel Capacity 480 per stairs. 4A and 4B travel downwards in a scissor like manner. Stair 4A traveling up has a travel occupant capacity of 240 persons.

Door 4A and 4B has a occupant travel of 480 persons each.

Stairs 8A and 8B Occupant Travel Capacity 480 per stairs. 8A and 8B travel upward and downward scissor stairs.

Door 4A and 4B has a occupant travel of 480 persons each.

THIRD FLOOR (41'-00") 1

1/16" = 1'-0"

N

FIRE RESISTANCE RATING DESIGNATION
1 HR.
2 HR.
3 HR.

Sheraton Phoenix Downtown HOTEL

DOWNTOWN PHOENIX HOTEL CORPORATION

TynanGroup Real Estate Development Services

3D/I

ARCHITECT OF RECORD:

ARQUITECTONICA
801 Brickell Ave, Suite 1100
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GRAPHIC DESIGN:

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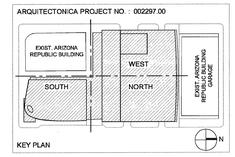
ARQUITECTONICA PROJECT NO. : 002297.00



KEY PLAN

SEAL / SIGNATURE / DATE STATE OF ARIZONA

SERGIO S. BAKAS - AIA #43444

CONSTRUCTION DOCUMENTS
PERMIT # LPRN-06004
QS: 11-28 SDEV: 0500952 DSD KIVA: 05-2376

Issue #	Issue Date / For
1	07.14.2006 / PERMIT SET
2	10.26.2006 / PERMIT RESUBMISSION
3	11.17.2006 / CONSTRUCTION SET
4	09.14.2007 / 8

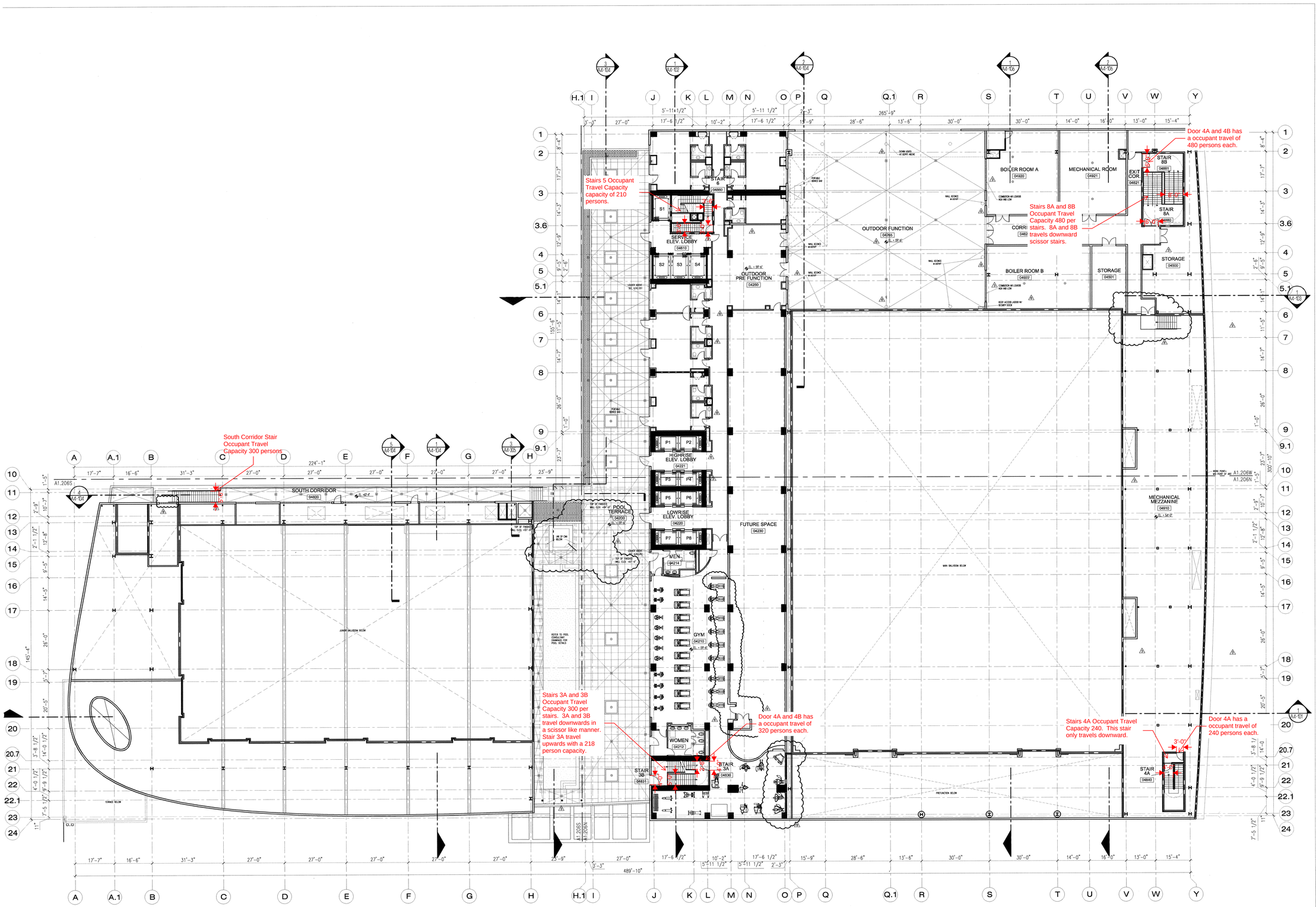
SHEET INDEX

THIRD FLOOR (41'-0")

SCALE : SEE PLAN

SHEET NO.

A1.105



FOURTH FLOOR (59'-6")

1/16" = 1'-0"

1

N

FIRE RESISTANCE RATING DESIGNATION

1 HR. ——————————

2 HR. —·—·—·—·—·—

3 HR. —··—··—··—

Sheraton Phoenix Downtown HOTEL

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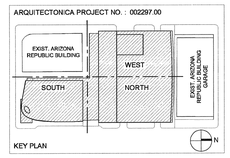

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SEAL / SIGNATURE / DATE STATE OF ARIZONA

REGISTERED ARCHITECT 33446 SERGIO BAKAS ARIZONA U.S.A.

SERGIO S. BAKAS - AIA #43444

CONSTRUCTION DOCUMENTS

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QS: 11-28 SDEV: 0500952 DSD KIVA: 05-2376

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4	09.14.2007 / 8

SHEET INDEX

FOURTH FLOOR (59'-6")

SCALE : SEE PLAN

SHEET NO.

A1.106